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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

MAY-OCTOBER.
North-East Coast Exhibition at Newcastle-on-Tyne.

JULY 16-27.
International Aero Exhibition at Olympia, London, W.

Institute of British Foundrymen.

Lancashire Branch (Junior Section):—Visit to the works of Messrs. Hy. Wallwork & Company, Limited, Roger Street, Red Bank, Manchester.

The Convention Papers.

We have commented recently on the large group of exchange Papers that were presented to the I.B.F. Convention early in June. These inevitably varied very widely both in treatment and in subject. As far as the other Papers were concerned, however, they afforded an altogether admirable balance of the interests that the Institute represents.

The non-ferrous interest was particularly well represented, the Papers being good and well discussed. It may be said here that the I.B.F. has recently been extremely fortunate in the contributions it has received on these subjects. The steel-founders, too, were catered for with a useful and interesting Paper, although unfortunately time for adequate discussion was lacking. The metallurgical interest was represented by three separate Papers on the influence of chromium, manganese and nickel respectively. In addition there was the burning question of testing methods, which resolved itself into a struggle between the French and the British points of view. Unexpected and welcome support for the British point of view was forthcoming from Belgium. The whole question, however, appears to be at something of a standstill, although it must inevitably be taken up again in the near future. So far as engineers' acceptance tests are concerned, there is no doubt that both points of view are leading to the same goal along entirely different tracks. There is, moreover, a measure of agreement on the possibility of using a shear test of the French type for investigating the properties of the casting at various points.

Lastly, on the more practical side there were excellent Papers on the highly pertinent topic of pulverised fuel. In particular the Paper on coal-dust was original in treatment and practical in conclusion, and it was an extremely sound idea to show in the technical exhibit at the exhibition samples of the work done during the investigation.

Taking the Papers as a whole, they were well presented, and, possibly as a result of the time-limit imposed upon both the introducers and the speakers in the course of the discussions, what was said was usually to the point. There was, too, a welcome absence of the platitudes that are not infrequently indulged on these occasions—welcome because they are no contribution to the serious business whose conduct is the real object of these sessions.

How We Stand To-day.

We find ourselves very considerably indebted to Mr. J. W. Bolton, who presented the Exchange Paper to the International Foundry Congress on behalf of the American Foundrymen's Association, for having answered the series of questions posed in this column after studying Mr. John Shaw's Paper presented to the A.F.A. last year. If we judge modern thought on the subject correctly, we find the position at the moment to be, roughly, as follows:—There is a clear conception that it is the soundness of the casting which is of paramount importance. That for the sake of progress and in order to aid the designer tests of an understandable and readily appreciable, yet truly characteristic, nature must be taken. That the form of the graphite is now considered to be the determining factor, and that it is desirable that the measurement of its size should be based on a mathematical basis; whilst this is being done, sight must not be lost of the control of the matrix. Here it seems desirable to state that much progress is being made with the Perlit process, and this is in no small measure due to the periodical meetings of the Licensees' Association, and is a concrete instance of the value of control and co-operation. The question of internal strains is relatively easy of solution. Enlightened design and the submission of the casting to a suitable after-heat treatment should minimise the danger of this factor. The question of gas-content control is not gaining much influential support, beyond assuring conditions so that no evolution will take place at the period of solidification with the obvious result in inducing blow-holes and spongy places. Ingotism, too, can be relegated to the background, as its evils can be overcome by normal metallurgical means. The last factor, that of the quality of the raw materials, is now much better understood and seems to be definitely related to the condition of the graphite, and this particular inherency is capable of rational explanation. In outlining these generalities, we are aware that the future may introduce radical changes in our conceptions of the relative importance of the various factors, but, at the moment, those in control of foundries would do well to standardise on the following factors as making for progress and quality:—(1) Rationalise design; (2) control as far as possible the graphite formation of the casting; (3) reproduce the matrix found to be the most suitable for the job in hand; (4) search for, and carry out, a test which will reflect the true properties of a casting and at the same time be helpful to the designer and inspector; and (5) make sound castings at an economic cost. Most other problems are resolvable with the available metallurgical knowledge.

XUM

Chains of Alloy Cast Steel.*

BY DIPL.-ING. H. KREUTZ V. SCHEELE.

Upon the subject of cast-steel chains, whether of ordinary or alloy steel, singularly little has been published, although there must be few foundries that have not occupied themselves at some time or other, even if only experimentally, with this question.

At the present day, steel from the electric furnace forms the sole material for the casting of steel chains, as only thus is perfect quality assured throughout.† Up to now, manufacture has been confined in the main to heavy chains of unalloyed steel—such as anchor chains and chains for dredging purposes. Foundry problems are naturally simplified in the case of heavier links, and, also, it is particularly with heavy chains that the higher tensile values of cast steel as compared with forged chains make themselves felt, thus facilitating competition.

It is certain, however, that the manufacture of cast-steel chains will greatly develop and that in the future alloy steel will be applied to the lighter chains. Three classes may be indicated:—(1) Heat-resisting and rustless chains of high percentage chromium steel; (2) wear-resisting chains of cast steel containing a high proportion of manganese; and (3) chrome-nickel steel chains.

Superheated steels containing a high percentage of chromium or manganese fill the mould well and give sharp castings. The liability to piping of these steels is, however, a source of great difficulty in chain making, and special precautions must be taken to obtain a casting sound and dense throughout. X-ray methods of examination can here be adopted with advantage. The alloy cast-steel chain will naturally be subjected to careful heat-treatment suited to its constitution and intended use.

A simple and at the same time dependable moulding technique is the basic economic factor for the successful manufacture of lighter chains from alloy cast steel. The moulding methods for anchor chains described by Irresberger‡ are for this purpose too involved and too costly. The author illustrates a mould for a "continuous" core-moulding process for a 10-mm. thick chain of manganese steel. The mould is composed of four quarter-cores. Two of these otherwise identical quarters have gates formed in them. Moulding can be done by apprentices, and is performed on the jar-ramming machine. The assembled cores can be joined together to any desired length. Separate lengths of chain may also be joined up in a second cast by inserting half of the end links in new cores. It cannot be denied that, at first, some difficulty is likely to be experienced in the horizontal casting of the links. On the other hand, the properties of the manganese steel are such that a small amount of piping in the steel may be permitted.

A manganese steel chain having links 10 mm. in thickness and moulded as just described broke at a load of 8,680 kgs. (18 tons 7 cwts.). The composition of the steel was as follows:—C, 1.15; Si, 0.30; Mn, 12.20; and P, 0.070 per cent. The chain was quenched in cold water from 1,050 deg. C., and then tempered for two hours at 200 deg. C.

In the case of cast-steel chains having a comparatively small proportion of alloying elements, where the main consideration is high tensile strength—the chrome-nickel steel chain, for example—the so-called "discontinuous" core-moulding method has its advantages, as thereby the casting of horizontal links can be completely avoided. With this method, individual and separate links are made at the first cast, using ordinary two-part cores, and these links then inserted horizontally in the above-described four-part core moulds for the second cast.

* Slightly condensed from "Die Giesserei," No. 13, 1929.
† This statement should be accepted with reserve.—EDITOR.
‡ "Giesserei-Zeitung," XVI, p. 132.

Sulphur in Cast Iron.

Inter-Relationships with Silicon and Manganese.

Discussing Mr. K. Gierdziejewski's Paper on "The Desulphurisation of Iron and Steel," presented to the International Foundry Congress, and printed in our issue of June 20, page 465, MR. F. J. COOK said that, whilst the Paper would undoubtedly be an interesting and useful one, he could not subscribe to what he called the underlying idea of it. The author seemed to point out that sulphur in any degree is bad for cast iron, and he personally could not subscribe to that. Generally speaking, he believed it would be found that it had been proved by a good many workers, and particularly by Coe and the late Dr. Stead, that there is no gain in physical properties in cast iron where the sulphur was below 0.07 per cent. Another point which cropped up in connection with this matter was mentioned when Coe presented his Paper at the Cardiff Convention many years ago, viz., the relation of the sulphur to the silicon. In getting out data in connection with high-duty iron, some 33 years ago, he himself had been struck with the fact that the highest physical properties were obtained when the sulphur was in the proportion of one-tenth the silicon. That was borne out very strikingly by Coe's work, but he had not noticed it at that time, and he (Mr. Cook) drew attention to it in the discussion on Coe's Paper. He had had subsequent correspondence with Coe, who, as the result of checking over his results obtained during a number of years, said he was surprised to find how frequently this ratio of 1 to 10 was associated with the highest physical properties of each series of tests. As the result of practical observations in the foundry, both with malleable iron and grey cast iron, this fact had impressed him, and had continued to do, although he had no scientific proof why it should be so, and it would be of value if the author could give any data on the subject, as well as in confirmation of the statement in the Paper that the physical properties are improved by the total elimination of sulphur.

MR. JOHN SHAW said he was not in agreement with Mr. Cook's suggestion as to the sulphur being one-tenth the silicon. This was satisfactory when dealing with an iron in which the silicon was 1.2 and the sulphur 0.12 per cent., but when dealing with a soft iron in which the silicon was 3 per cent., should the sulphur be 0.3 per cent.?

MR. COOK: Yes.

MR. SHAW said that was contrary to anything he knew. His experience, especially in the lower grades of iron, was that a great deal more depended upon the relation of the manganese to the sulphur than upon the relation of the silicon to the sulphur.

MR. J. T. MACKENZIE (American Foundrymen's Association) said that the sulphur problem is not particularly keen in America at the moment, but at one time during the war it was very serious. In the casting of a pipe when the metal might fall 16 ft., there might be motion at the bottom of the mould, and anything like a sulphur ratio of one-tenth the silicon would result in the accumulation of manganese sulphide in the bottom of the casting if the metal was sufficiently hot. If it were not sufficiently hot, there would be blow-holes in the bottom. Through the reduction of the sulphur from 0.12 to 0.07 per cent. that difficulty was overcome. He did not think the silicon/sulphur ratio was quite the determining factor, and the manganese must be brought in.

ERRATA.—Mr. Ben Hird points out that Fig. 9D of his Paper was printed upside-down, and that at the foot of the first column on page 6, "carbon absorption showing a gain of 0.181 per cent." should read "0.191 per cent."

Random Shots.

Those of you who shared my experience and heard something of the views of our American visitors last month—views which have already been discussed at some length in this journal—would be interested to read, if you have not already read, the latest novel of that somewhat notorious American novelist, Mr. Sinclair Lewis. This book, "Dodsworth," would interest you, I think, because it is almost entirely concerned with the reactions of an American business man to English and European conditions. Let me give an instance. More than one of our visitors remarked that the time devoted to mere finish in a certain famous Midland works—which shall be nameless—seemed to American eyes an utter waste. Mentioning this to a friend, he turned up the page where Mr. Samuel Dodsworth, in the novel aforementioned, makes the identical comment on the identical works! You read it—or skip it, if that is more to your fancy!

* * *

I have been amused by recent ecstatic comments in the Press on the originality of a certain young modernist sculptor who makes use of aluminium, and, still more remarkable, of cast iron, in his work. One writer even apostrophised his (female) readers in something this style: "When you gaze upon your commonplace kitchen range, does it ever occur to you that here to the artist's hand is a new and wonderful medium, etc., etc."—you know the style. The young modernist in question is apparently so modern that he is ignorant of any save entirely utilitarian purposes for cast iron—whose artistic possibilities have been extensively explored, if our memory is not playing us false, both in Germany and in Sweden. But perhaps the young man himself is not responsible. Oh, publicity, what crimes are committed in thy name!

* * *

Have you heard of the latest method of improving your finances? You write to persons resident in foreign countries and tell them that you are making a collection of current coins, and would be obliged if they would send you some specimens. . . . Here are a few extracts from the letter I was shown:—

"The writer is trying to make a collection of monies from different countries, and would appreciate your sending him a collection of the money of your country up to the unit, . . . the names of each coin, and its value up to the unit. . . . When sending these coins by registered post, please advise your charges so that I may reimburse you for same. . . ."

Neat, isn't it? But forewarned is forearmed in a case like this!

* * *

The memoirs of the celebrated Yvette Guilbert have recently been translated into English, and they contain some entertaining stories. One of the best of these tells of a visit of the late King Edward, when Prince of Wales, to a well-known Parisian restaurant. He was surprised to find that the peaches were 25 francs—25 francs in those days being the equivalent of a pound sterling.

"Peaches must be very scarce this season," he said. "I won't eat any more."

"Your Highness," the maître d'hôtel told him, "it is not peaches that are scarce, but princes."

It is added that the bill was paid with a smile!

MARKSMAN.

Methods of Testing Cast Iron.*

By A. le Thomas and R. Bois.

[FRENCH EXCHANGE PAPER.]

The question of testing cast iron, which has so greatly interested foundrymen of all countries for several years, has long been studied by numerous investigators, but that agreement which is so desirable as to the choice of the tests to be adopted and the most suitable method of carrying out tests on castings has not yet been reached. Ought the tests employed to be tensile, shock, shear, static-transverse or hardness tests? Ought the test-pieces to be cast separately or taken from the castings?

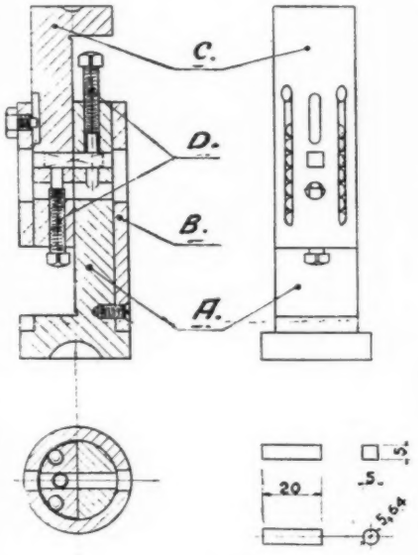


FIG. 1.

(A) HALF-CYLINDER FIXED IN SOCKET; (B) SOCKET; (C) FREE SEMI-CYLINDER; (D) TIGHTENING SCREW.

The question at present is to ascertain how a machinery casting ought to be tested. One of the authors has already described his method,[1] which consists in applying the shear test or the static-transverse test to bars taken from the castings, or by ball-testing the castings themselves. The old method, which is upheld in opposition to this, is to carry out tensile, static-transverse and shock tests on bars cast separately.

In order to define their standpoint on the questions forming the subject of this Paper, the authors find it necessary to examine the views which are opposed to their convictions and which are for the most part contained in a Paper presented by Mr. J. G. Pearce, Director of the Cast Iron Research Association, to the Sheffield branch of the Institute of British Foundrymen. The search for truth on this subject, at present but imperfectly understood, demands, in fact, absolute freedom of judgment and an absence of all prejudice, and it is in this spirit that the authors have quoted a number of passages from Pearce's Paper for the purpose of criticising them.

The Choice of Mechanical Tests capable of Determining the Intrinsic Characteristics of Cast Iron.

The principal tests that occur to one when it is desired to study the properties of a sample of metal are the tensile, transverse, shock, shear, compression, torsion and hardness tests. All of these have been used indiscriminately for cast iron by experimenters, who, unfortunately, have not always considered the significance of the results of their tests.

A brief review of the examination of the shock and tensile tests which Frémont and Portevin had absolutely condemned in the course of their work is given below. The force of habit and routine is so great that it is deemed necessary to give a short summary of their arguments, for nothing is more difficult to get accepted than evidence regarding original research, while the authors will be well satisfied if they succeed in reducing the too-large number of foundrymen who persist in their error.

Examination of the Tensile and Shock Tests.

The different mechanical tests at present in use provide a certain number of coefficients as shown in the following table (1):—

Tests.	Elastic deformations.	Permanent deformations.	
		Resistance to deformation.	Deformation capacity.
Tensile ..	Mt Et	Rt	A
Transverse ..	Mf Ef	Rf	f
Shear ..	Ec	Rc	—
Hardness ..	—	—	—
Shock ..	—	—	a
		p	

M indicates the moduli, E the elastic limits, R the breaking strength, A the elongation, f the transverse-breaking deflection, p the resilience, The tensile test should give the modulus of elasticity, the elastic limit, the breaking tensile strength and elongation at the point thereof. In the case of cast iron, however, as the elastic limit is almost the same as the breaking load and the elongation is almost nil, the only result, which the usual test can give, is the breaking strength. "The elastic deformations being very small (the moduli are something like several thousandths) they cannot be determined by this type of test except by having recourse to delicate processes (such as the mirror method, elasticimeters or the Guillery method). The use of these processes shows that pure tensility is an illusion; it is enough to observe elastic deformations on one or more of the jaws associated with the same cylindrical test-bar to find that there are always unequal differences in the value and even in the direction of the deformations produced, which shows the existence of parasitic stresses which complicate the tensility."[9] It follows, moreover, that these parasitic stresses completely mask the result of the test; the rupture almost invariably takes place in the jaw where the head is held, and it is due to this stress which the cast-iron test-bar will resist the less in proportion to the lowness of its quality.[4] The tensile test, therefore, which is of interest only inasmuch as it gives, in the case of any metal, the elastic limit and the contraction of area (and not, as is generally believed, the breaking strength and elongation),[5] is not merely incapable of doing so in the case of cast iron, but it also gives a breaking strength which is entirely incorrect. It is, therefore, absurd to continue its use. It is not thought, moreover, that such a change in practice would cause any particularly serious inconvenience to the inspection and control services or the laboratories already equipped for these tests. It is true that this opinion is not generally accepted. "These disadvantages," according to Pearce, "might be considered sufficient to condemn the testile test for cast iron. The tensile test, however, is specified by certain engineers, certain foundries are equipped for this test and the inspectors are familiar with it, so that there is no apparent reason why the test should not be retained."

The authors have excluded it entirely from the Piat Concern's laboratory, and they only regret that certain public bodies have retained it for their inspection of castings.

Like the tensile test, the shock test has been used for cast iron in the same way as for steel,

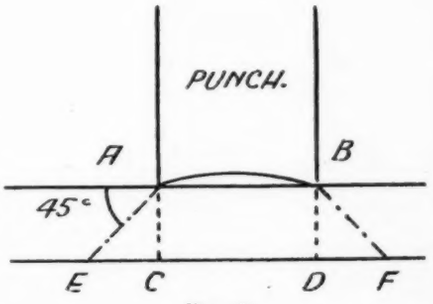


FIG. 2.

which is a serious mistake. "The rupture of cast iron is always intercrystalline; it separates the crystals whether the shear, transverse, tensile or shock test is employed. When any one of these test methods is applied the energy brought into action is always of the same kind."

This is not the case in regard to most of the other alloys; for example, in the very commonplace case of the rupture of steel, the fracture is intercrystalline (as in cast iron) when the shock test is applied, whereas it is intercrystalline under the tensile test. In steel, therefore, the stresses set up are of a distinct nature in the two cases in question and the total work is also different. Thus, the necessity of providing against the possibility of rupture during service will be apparent, either through a dynamic stress or a static stress, by carrying out these two tests, which, roughly, bring about the conditions which usually accompany such ruptures, hence the presence of both tensile and shock tests in specifications relating to steel.

But, as in the case of cast iron, the energy indispensable for static rupture and for dynamic rupture is identical, at least as regards its nature, it is useless to create a new method of testing, particularly in view of the difficulties experienced when this test is effectively carried out. In fact, the use of a small-scale rotating hammer, a 3-kilogrammètre Charpy hammer, for example, which eliminates the more serious faults to be found with the *chemin de fer* type of apparatus, does not give sufficiently accurate results to distinguish two irons of different quality. The energy required to break a test-

*A Paper presented to the recent International Foundrymen's Congress.

REFERENCES.

1 A. LE THOMAS: "Personal Experiences of the Application of the New Methods of Testing Cast Iron." (Paper presented to the Liége Congress of 1925 and the Detroit Congress of 1926.)
2 A. PORTEVIN: "Mechanical Testing of Cast Iron." (Report No. 3 presented to the Swiss Association for Testing Materials, in December, 1926.)
3 A. PORTEVIN: *loc. cit.*
4 See FRÉMONT: "New Methods in the Mechanical Testing of Cast Iron."
5 A. PORTEVIN: "Mechanical Tests and Strength of Materials." (Paper presented to the Congress of l'Association Technique de Fonderie, Nancy, 1922.)
6 A. LE THOMAS: *loc. cit.*
7 A. LE THOMAS: *loc. cit.*
8 GUILLERY: Note to the Académie des Sciences, October 8, 1917.
9 A. PORTEVIN: "Mechanical Testing of Cast Iron." (Report No. 3 presented to the Swiss Association for Testing Materials, in December, 1926.)
10 A. PORTEVIN and L. DESCROIX: "Revue de Métallurgie," February, 1928; the International Congress for the Testing of Materials held in Amsterdam, September 12-17, 1927.

bar of 55 × 10 × 10 mm. is 0.45 kilogrammètre, or 15 per cent. of the applied energy. The errors are also excessive in relation to the strength variations resulting from the differences of composition or structure. The shock test also should, therefore, be excluded from industrial or research laboratories.

Compression and Torsion Tests.

In a previous Paper[6] it has been explained why the compression test has been eliminated. This in itself is perfectly justifiable, as it gives an exact idea of the value of the metal under examination. It is useless, however, if the shear test has been carried out, as it gives an equivalent result and requires a machine which is

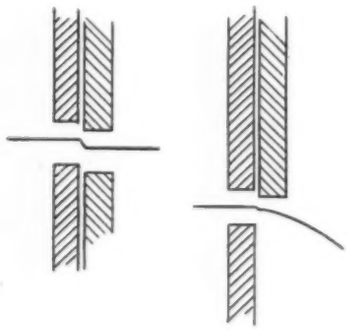


FIG. 3.—TWO LINES OF CONTACT BETWEEN TEST-BAR AND SHEARING ELEMENTS. ONE LINE OF CONTACT BETWEEN THE TEST-BAR AND SHEARING ELEMENTS.

very much more bulky and costly. As regards the torsion test, it appears to be employed only in Germany, where Prof. Rudeloff has selected it as the basic test in his work on the merits of the shear test. The authors do not use it because, as in the case of the tensile test, it appears difficult to get rid of parasitic stresses and to twist a cylindrical test-bar accurately about its axis. In any case, it is much more complicated than the shear test.

Shear, Static Transverse and Hardness Tests.

The authors have already explained at length[7] why they have adopted these tests. They will here consider the new machines used in carrying them out, and refute adverse criticisms. For the moment it is proposed to examine these tests only from an intrinsic point of view, reserving until later the study of their application to the problem of testing castings, which is entirely different from that now under consideration.

Shear Test.

For testing cast iron, the shear test is carried out on the Guillery machine, which consists of a ball-test machine, to which two loose pieces for the shear and the static transverse tests can be fitted. The device for the shear-test consists of a guillotine formed of two half-cylinders, one of which is fixed in a cylindrical socket, while the other slides in the space left free in the socket. Each of the half-cylinders is pierced with two holes, one square and the other round for testing the two types of test-bars. These are small bars about 20 mm. in length, with a section of 25 mm², the round being 5.64 mm. diameter and the square 5 mm. on the side.

As the two half-cylinders have a tendency to separate in shearing, the movable half-cylinder of the guillotine has a vertical row of balls, so that its displacement in the socket produces only a rolling friction. To carry out the test the bar is inserted in the rest and the screw is tightened by hand or very gently with a spanner, the end of which is fitted with a depth-gauge, which serves to adjust the position of the bar so that the shear takes place exactly at the centre. Having been prepared in this way, the device is placed beneath the ball-testing machine between the upper and lower balls; an increasing pressure is induced until rupture takes place; a pressure-gauge with maximum indicator shows the breaking load, which is then converted to the sq. mm. of section. When the test is properly carried out no premature rupture by bending ever occurs. For this it is necessary that the test bar, taken with a trepan drill, shall be quite cylindrical, and that the screws of the apparatus shall not exert too great a pressure on it in its bearings. The shearing rupture is always very clean. This apparatus, which is remarkably convenient to handle (its weight is 1.65 lbs. and its dimensions 114 × 40 mm.), enables a test to be made in a few seconds, and gives accurate and constant results.

TABLE I.—*Shear Test Results (Pearce).*

Reference.	Test.	Diameter of test-bar.	Special conditions.	Strength in kg./mm.
—	Tensile ..	14—.3 mm.		26.8
a	Shear ..	15.8 „	Double shear	33.0
b	„ ..	9.5 „	„	33.5
c	„ ..	5.6 „	„	33.2
d	„ ..	5.6 „	Double shear. One line of contact between the test-bar and the shearing element.	28.0
e	„ ..	5.6 „	Single shear	30.2
f	„ ..	5.6 „	Single shear. One line of contact between the testbar and the shearing element.	25.5

Criticisms of the Shear Test.

The use of the Guillery machine eliminates all causes of failure in the shear test, and it is probably the use of defective systems that have led to the belief that it is difficult to obtain a correct test. The objections raised are in fact numerous. In the first place it has been said that it is impossible to get rid of parasitic stresses (Pearce). In a paper presented to the International Foundry Congress of 1927 Hermann and Henguin, of the F.N.A. of Herstal-lez-Liége, quote in support of this objection the fact that the shear strength with the punching test is 20 to 40 per cent. greater than with the ordinary shear test, which, they say, must therefore be accompanied by a parasitic stress. But in the punching test the field-of-force of the reactions developed in the sample is differently distributed as compared with that produced by the shear test, and the rupture instead of taking place along the cylindrical surface takes place along the conical surface ABFE, the angle of opening being 45 deg. (Cf. Hypothesis of maximum slide). In rupture by shearing, on the other hand, the fracture takes place parallel to the stress imposed. The two tests are not therefore comparable.

In the other shear tests studied at Herstal, moreover, "owing to tolerances in making the test-bars used, transversal fissures characteristic of rupture under transverse load occurred in the course of the tests considerably in advance of rupture by shearing." The authors have never been able to observe anything of the kind with test-bars which were obtained with the trepan drill. Pearce has further criticised the shear test on the ground that it gives a result which varies with the conditions of the test—this opinion being based on the following experiments:—Shear tests were carried out on bars 15.5, 9.5 and 5.64 mm. diameter in a double-shear device combined with a tensile machine.

The results obtained are set out in Table I:—

From this Pearce concludes: "a shear-test thus does not measure an absolute value, but one which depends upon the conditions of the test." The authors are not of this opinion. A double shear is different from a single shear as regards the distribution of the stresses in the sheared sections, the more so as they are closer together, and the two cannot therefore be compared. It is enough, however, to choose once for all between these two tests. From these results, moreover, it is apparent that the double shears *a*, *b* and *c* are very concordant. The *d* and *f* tests, in the authors' opinion, are suspect, for a shear-test carried out in this manner ought certainly to show a considerable amount of bending, as shown diagrammatically in the accompanying sketch. For this reason there is a reduction of about 15 per cent. in the strengths shown, viz.: 25 kg. in place of 33.2 in the case of the double shear, and 25.5 kg. in place of 30.2 in the case of the single shear.

It is not by any means proved, therefore, that the shear-test gives variable results according to the method of operation employed provided it entirely eliminates the parasitic stresses. It has even been maintained that even when the same method is employed the result of the test may be variable. If this objection were well-founded, it would suffice to eliminate the shear-test altogether, for it would no longer possess the fundamental character of every criterion, namely that of being constant. Fortunately this is not the case. According to Pearce in the Paper already mentioned: "To see whether a regular relationship existed between the tensile tests and the shear test a variety of bars

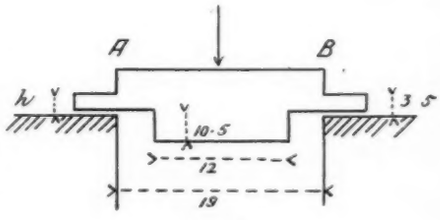


FIG. 4.

tested in tensile at 20 mm. (0.798 in.) diameter were also tested in double shear at 12.5 mm. (0.5 in.) diameter. The tensile shear ratio varied between 0.52 and 0.93. The constancy of this ratio is an important point in the French proposals for supplanting the tensile test by the shear test." The authors have never claimed to establish the value of the shear test in this way, and the inconstancy of the tensile test is sufficient to explain the variations of the tensile shear ratio between 1 and 2.

For this reason also it is illusory to look for any relation whatsoever between shear strength and tensile strength. Certain writers have thought, moreover, that the machining of the test-bar must be very accurate (Pearce) and that the trepan drill is incapable of ensuring the necessary precision. According to Elliott* "Trepanning gives rather inaccurate test-bars. . . . Even when grooves were made to release the swarf in the drill it was found somewhat difficult to obtain accurate test-bars." For their part, the test-bars which the authors take daily

* Paper presented to the Detroit Congress in 1926.

from the castings are always exceedingly uniform, and fit perfectly into the holes of the shearing guillotine.

Finally, the slight tool marks left on the shear core by the hollow drill has been regarded by some as a fatal defect. "The drill," according to Pearce, "does not leave the test-piece with sufficiently good finish for a shear test, which should be machined as fine as possible; whilst Mr. Walter Wood, in a letter, dated October 7, 1926, to the Cast Iron Testing Commission of the Association Technique de Fonderie, states: "We all know that a test-bar taken with a drill shows tool marks to a greater or less extent. It appears to me that whatever the dimensions of the test-bar taken may be, the tool marks ought to be remedied."

Tool marks, however, as Portevin has pointed out, which have a considerable influence when the surface undergoes longitudinal extension, exercise only a secondary influence in the shearing of cast iron. "No one thinks," he says, "of asking that the accuracy of the direction of the tensile stress, which is fundamental in cast iron, should be controlled, yet there are those

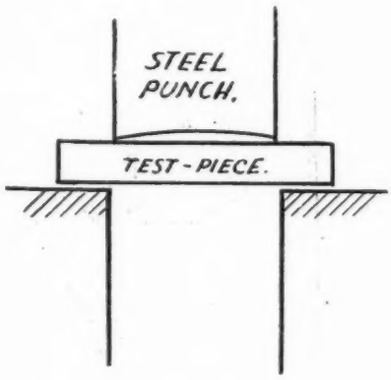


FIG. 5.

who worry themselves about tool marks on shear-test bars." The authors cannot do better than express their approval of this observation without making any comment.

It should be pointed out, however, that Mr. Walter Wood's criticism is perfectly justified if the drill used cuts badly, for in that case the tool marks are no longer mere traces but actual holes and furrows all over its surface. A drill that has been properly made produces almost perfectly smooth test-bars.

The Shear Test by Punching.

The Germans have studied and perfected a method of shearing by double punching, and a summary of their work on the subject has been published by Rudeloff, in two Papers which appeared in "Stahl und Eisen," on January 28 and December 23, 1926.

Karl Sipp had examined a new shearing process for cast iron in a Paper published in "Stahl und Eisen" (XL, pp. 1697-1704, 1920), under the title of "The Shear Test and its Application to the Study of the Mechanical Properties of Cast Iron." The test which he recommended was that of shearing a disc by punching, the result being to form a flange round the disc.

Rudeloff made certain modifications in this test. To obtain a better distribution of the stresses he tried different kinds of surfaces (AB) and adopted a surface with raised edges. Moreover, as the flange formed by punching was always breaking, and as the additional work involved marked the measurements, he decided to saw it radially in three directions as far as the vertical of the sheared section. Finally he reduced the height h of the flange in order to eliminate parasitic stresses. This modification of the method was studied systematically simultaneously with the torsion and double-shear tests on a Martens machine, which very much resembles the small Frémont machine, and Rudeloff made the following deductions from his experiments:—*Double-shear strength* = 0.946 × torsional-shear strength; *Sipp-punching strength* = 0.981 × torsional-shear strength, and *Tensile strength* = 0.81 × torsional-shear strength; and he concludes: "It must be admitted that the true value of the shear strength is given by the torsion test" (because it is the greatest) . . . and "If the test conditions are well chosen the modified Sipp test is capable of giving a value closely approximating to the true (?) shear strength. This test gives more exact values than the double-shear process on cylindrical test-pieces and rings with an internal diameter equal to the external diameter of the test-pieces."

The test was then slightly modified, the test-piece being a plain disc, sawn radially and sheared with a steel punch. Having experimented on a certain number of different cast-iron bars, Rudeloff found that *Punching-shear strength* = 0.91 × Sipp-shear strength, and from this ratio and those established by him for the Sipp-shear test he determined all the ratios enabling all the constants of the metal tested to be calculated from that test.

These two Papers describe a method of shear testing which is not without interest, at least theoretically. The extent of the first experiments by the Sipp method was, according to Rudeloff himself, somewhat limited; the tests were not numerous and the conclusions are based on calculations which are too precise for a material so lacking in homogeneity as cast iron.

This critical study of the Sipp method, nevertheless, leads to improvements which eliminate certain parasitic errors (bursting of the flange). It does not, however, eliminate a bending which is due to the disc not being supported in the interior of the matrice and which is not entirely suppressed by the fact that the shearing force is applied almost at right angles to the matrice. (The ratio-punch diameter : matrice diameter varies between 0.97 and 0.98.) This, however, is not the principal objection.

Why select the test which gives the strength that has the highest value? It does not on that account possess any greater value as a criterion than a test which determines a property showing a lesser figure. What, then, is this "true shear strength" of Rudeloff? If the Sipp test comes nearer this result for the alleged reason that $R_{sipp} = 0.981\ R_{torsion}$, while $R_{double\ shear} = 0.946\ R_{torsion}$, why not adopt as criterion the torsion test itself, which is simpler and more definite? The special value of the Frémont shear test is that it enables cast irons to be classified according to their merits in service and that it is extremely simple. Even admitting that the Sipp test constitutes a good criterion, the fact nevertheless remains that it is much less easy to apply (lathe machining the test-piece, radial sawing of the plunger, the employment of a load of 5 to 10 tons). The test-piece sheared with a steel punch is no doubt a little simpler. But the substitution of a punch for a piece applied to the cylindrical extension partially remedies a bad distribution of the stresses. It leaves the parasitic bending still existing. It appears, moreover, to bring the hardness of the test-piece into play, for the punch must penetrate the disc before the shearing.

Finally, the ratio between the two strengths thus obtained is untrustworthy. It is based on only a few experiments, of which there are no details. It is, therefore, hazardous to calculate the transverse, tensile and compression strengths as a function of the double-punch strength, particularly in the case of material of such imperfect homogeneity as cast iron and with the help of but a few experiments; and this, moreover, is perfectly useless if the double-punch test is an adequate criterion for the classification of iron.

Even if double punching were found to be a good criterion as a result of very prolonged experiments, such as one of the authors carried out at Indret in regard to the shear test, the difficulty in machining the test-piece would still remain. In the case of a circular disc a few millimetres thick and a few centimetres in diameter, sawn radially as far as the circumference of the punch, the difficulty is much greater than in that of the Frémont trepanned core. If the shear test appears of service in interpreting the mechanical properties of metals, it is useless to recast Frémont's researches and to seek for a method of applying this test which has the appearance of being original, but which is, in fact, much more complicated.

Static Transverse Test.

At present the authors utilise the static transverse test on Frémont test-bars 8 × 10 × 35 mm., with the Guillery apparatus adapted to the ball-testing machine. This static transverse apparatus consists, roughly, of a main body, composed of two supports 30 mm. apart, on which the

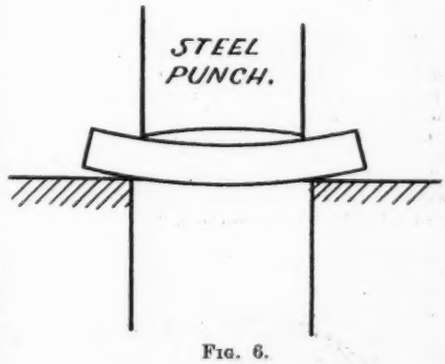


FIG. 6.

two ends of the test-bar rest, a knife-edge, which rests upon it at the middle, and a cylindrical socket, which takes the lower part of the main body, Belleville washers being interposed.

The semispherical hollow head of the knife edge receives directly the force exerted by the ball-testing machine, while the lower socket bears against a fixed block. The breaking load is indicated by the maximum gauge of the ball-testing machine.

The tracing of the deflection-load diagram and consequently the measurement of the breaking deflection are effected as follows: A frame, which is covered for each test with a paper coated with baryta, is mounted movably about a fixed horizontal spindle attached to the main body of the apparatus. By means of a spindle carrying a geared piece and resting on a conical piece with rack-tooth incline it is caused to rotate to an extent proportionate to the relative displacement of the lower socket and the main body, that is to say, practically proportionate to the loads transmitted by the bar to the main body. The deflection to which the bar is subjected is, moreover, transmitted by means of a contactor and an amplifying lever integral with the main body to a brass registering stylus. The movements of the stylus and the frame take place in two rectangular directions, the stylus finally tracing on the sensitive paper the deflection-load diagram in the form of a system of curvilinear co-ordinates. A transparent graph placed over it enables the breaking deflection to be read with an error less than 0.1 mm. The breaking load measured by the gauge is given within about 2 kg.

The play of the parts is eliminated throughout by an appropriate arrangement of springs, and the accuracy of the measurement is superior to

(*Continued on page* 32.)

The Problem of Foundry Moulding Sand.*

By H. Van Aarst.

[*Presented on behalf of the Dutch Foundry Technical Association.*]

For several years the author has made many experiments with moulding-sand, and as a result prefers synthetic moulding-sand, as all natural sands, both as regards grain-size and the clay content, are very irregular.† From the beginning of 1928 the author has prepared loam, moulding-sand and core-sand, using only river-sand, sea-sand, dune-sand and clay. The composition of these sands are outlined in Table I.

TABLE I.

——	SiO_2	H_2O	Al_2O_3	Fe_2O_3	CaO
River-sand ..	94.00	3.70	1.10	1.00	trs.
Sea-sand	98.01	3.86	2.04	0.46	4.50
Dune-sand ..	90.60	5.39	2.44	trs.	1.40
Clay‡	65.00	20.99	10.26	2.92	0.78

‡ This shows many variations and consequently it must be regularly controlled.

The loam consists of fine river-sand, which is mixed up with undried clay, to which flax-waste and fine coal is added. Figs. 1 and 2 show two castings, made without a pattern, and cast in this loam. Fig. 1 is the half of a centrifugal pump (principal dimensions: length 4,250 mm., width 1,600 mm., height 2,750 mm., diameter of delivery tube 1,400 mm., weight 9,000 kg.; time required for casting, 45 sec.). The other casting is a stern tube for a motorship, which was cast vertically (time required for casting, 3½ in.; length 6,600 mm., weight 11,000 kg.).

FIG. 1.

Moulding-sand for dry moulds is made of fine river-sand, clay, flax-waste and fine coal, mixed dry. In this sand both locomotive cylinders

FIG. 2.

and the heaviest type of foundation-plates are cast. It is also used for lighter castings, but it is then made up of a finer grain and without flax.

For core-making sea- or dune-sand is almost exclusively used, but for very large cores fine river-sand is prepared. The sand is dried until quite free from water. Linseed-oil is mainly used as a binding-material.

Routine Testing of Sand.

The sand is tested daily for controlling the grain-size. All the various mixtures of loam or sand are controlled to conform to fixed dimensions, and, according to their ultimate use, suit-

MR. H. VAN AARST.

able samples are dried at the same temperature as the moulds. The temperature of the stoves is registered automatically on a "Cambridge-Thermograph." The drying-stoves are heated with coke-breeze in a "Herrmann" furnace. With some few exceptions, the temperature of sand- and loam-moulds is not higher than 400 deg. C., whilst for the cores 225 deg. C. is not exceeded.

The author has designed an apparatus for testing the density of sand which resembles that of Shäw (see Fig. 3). After opening the cock B the compressed air streams through the coil A and through the cake of sand under test. The nozzle, placed on the cake, has a rubber ring at the lower side. Round the coil, above the nozzle, a piece of lead is attached, so that the rubber rings completely shut off the sand. On the scale D the resistance in mm. can be read which is imposed on the air in passing through the sand. In Table II some differences in pressure are stated for loam, clay and core-sands. In the second column all figures are the same. Possibly in reality these figures are higher, but higher figures cannot be measured with the apparatus.

In the FOUNDRY TRADE JOURNAL of December 6, 1928, Mr. C. Presswood deals with the various contradictory opinions regarding the porosity of moulding-sand. The following explanation may commend itself: the blackened skin of the mould almost entirely prevents the gases from exhausting through the sand to the open space of the mould, so these gases have to find their way chiefly through the vents; further, they press on the mould and consequently partly prevent the gases behind the blackened skin (the gases which have developed there) from exhausting to the inside of the mould or through the liquid iron.

TABLE II.

——	Untreated	Black washed.
Loam	370	950
Loam for hot melted iron ..	460	950
Sand for dried moulds ..	300	950
Core-sand for large moulds ..	60	950
Core-sand for light moulds ..	110	950
Core-sand for hot melted iron	450	950

Thus such a mould can be compared with a chill mould, in which steel is cast, or with a permanent mould. The sand behind the

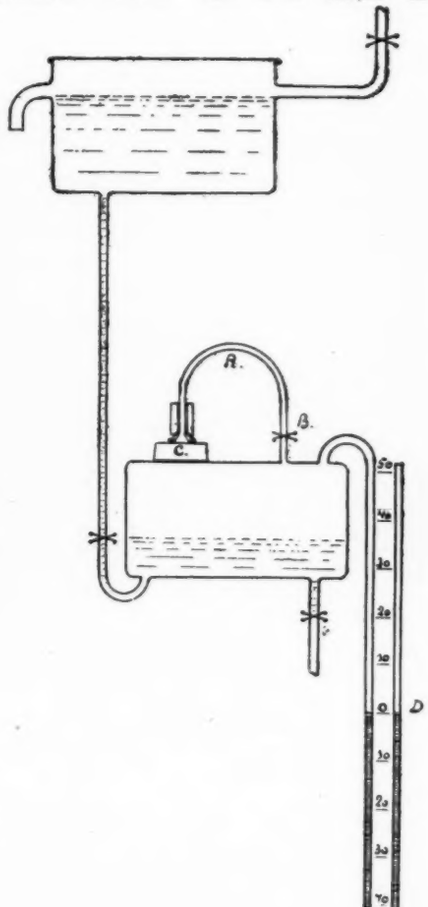


FIG. 3.

blackened skin cannot be too porous. This is best seen when pouring a casting of some importance, moulded in the floor. The gases exhausting from the coke-bed very often have such a velocity that they escape from the exhaust-

FIG. 4.

tubes whistling. When these gases encounter obstructions one may count on having a faulty casting. Table II, therefore, is of much importance.

* A Paper presented to the recent International Foundrymen's Congress.

† "De Gieterei," 1927, pp. 30-36.

The Influence of Graphitisation of Cast Iron.*

By E. Diepschlag, Breslau, Germany.

[GERMAN EXCHANGE PAPER.]

At an International Foundry Congress held in Paris in 1927, M. André Levi[1] made a remarkable statement as to the transmission of properties in cast iron. Proceeding from the well-known fact that two different samples of cast iron of the same chemical composition often have very different mechanical properties, he established that, in addition to the chemical analysis of a metallic material, some other characteristic factors must be derived to predict it exactly, and in the case of cast metals the previous thermal history must especially be taken into consideration. By this, the rate of heating of the material, the degree and time of superheating and the rate of cooling is understood. The chemical composition and the previous thermal history are, in many cases of metal alloys, two independent values, and for a given chemical composition the mechanical properties may be predicted when the earlier thermal history is known.

However, in grey cast-iron materials, these two determining characteristics are not independent of each other, as it is nearly impossible to modify the speed of cooling, for example, without at the same time changing the chemical composition. The carbon present in a cast iron is determined by chemical analysis to exist partly as graphite and partly as combined carbon, and the proportion of these two parts is modified in relation to the thermal conditions. In the case of cast iron of a given chemical composition, the mechanical properties are not exclusively determined by the previous thermal history; therefore, a new value must be considered—peculiar to cast iron—which is recognised by Levi as a transmissary property. This third value is caused by the influence of the thermal history on the chemical composition and the chemical reaction of the alloy under the influence of heat.

An Explanation of Inherent Properties.

For the separation of crystals from a saturated salt solution, it seems possible, in reference to the size of the separating crystals, to produce a forced crystallisation. Thus, if the first crystals appearing or actually present are very small, the later separating crystals will be small also, and *vice versa*. Therefore, if a cast iron having coarse-grained graphite crystals is melted and then cooled down, the remelted sample will have similar coarse-grained graphite deposits, unless, through a high superheating, the nuclei are totally destroyed. In most of the common remelting processes the superheating temperature and time is insufficient to destroy the nuclei completely. Consequently, a remelted cast iron is associated with coarse-grained graphite if the original material was so constituted. On the contrary, when remelting cast iron having fine-grained lamellæ, they are again found in the alloy after remelting. Thus, the structure of a pig-iron or scrap used for remelting purposes is largely reproduced in the final product, and in this sense it may be spoken of the transmission of properties.

If one tries to reconcile the chemical composition of an alloy and its mechanical properties generally, there is only a qualitative relationship between the amounts of the constituents and these properties. In the case of cast iron, however, the influence of graphite heavily predominates all other constituents. It is true the development of the matrix to perfect the mechanical properties has attracted much attention during the last few years, and the steps taken to obtain a ferritic or pearlitic matrix have been very fully outlined. But, in this connection, it was recognised that all improvements of the matrix are masked by the existence of more or less large quantities of graphite being distributed throughout the mass in diverse orientations.

Overcoming Inherency.

P. Bardenheuer and K. L. Zeyen[2] established from their experiments that an annealed chilled cast sample had better mechanical properties, even though it had a ferritic matrix, than a sand-cast sample having a pearlitic matrix. They postulate from this that the structure of the metallic constituents is only of minor importance in relation to the mechanical properties of grey cast iron, and that, in the main, the form and the distribution of the graphite is decisive. Thus, with regard to the quantity, the form and the distribution of the graphite, only after the most favourable conditions are created, the question of the formation of the matrix becomes important.

So if, on the one side, the relationship between the mechanical properties and the chemical composition really refers to the ratio between these and the quantity and form of the graphite, and, on the other hand, as postulated, a transmission of the structure of the pig and scrap iron taking place in normal remelting methods, founders must study these metallurgical questions, not merely as to the final product, but with similar assiduity to the quality and properties of the metallic raw materials employed. The most important raw material in this case is the pig-iron. This must not only be evaluated according to its chemical composition, but rather with reference to the type and quantity of the graphite content. The graphite is mainly responsible for the tensile strength, and these properties are modified by remelting—only slightly, never completely.

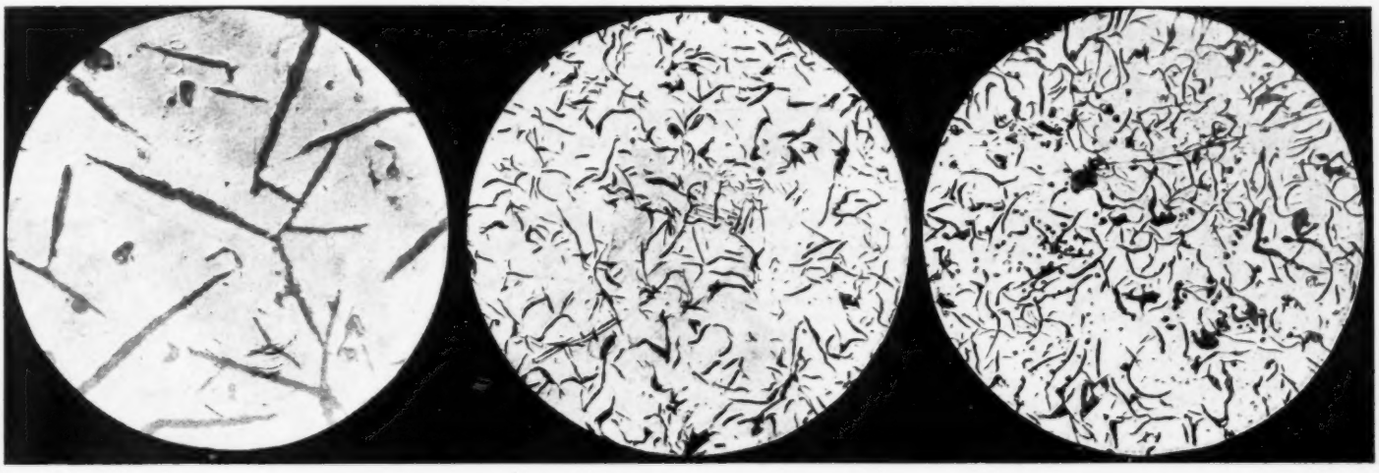


FIG. 1. FIG. 2. FIG. 3.

How Blast Furnace Conditions Affect Final Product.

During smelting in the blast furnace, after the reduction of the iron ores, the metal mainly dissolves the carbon in the zone of highest temperature, that is, in the furnace hearth. It may be supposed that in the neighbourhood of the tuyeres the iron is nearly saturated with carbon. During the dropping of the iron to the bottom of the furnace a re-separation of the carbon begins whilst the pig-iron is still in the furnace. Old blast furnaces making foundry pig-iron often show, after blowing out, a quantity of graphite on the hearth lining. In other cases it is possible that, by the reduction of sili-

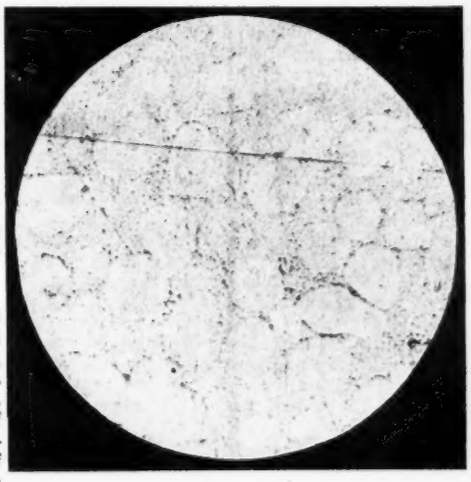


FIG. 4.

* A Paper presented to the recent International Foundry Congress.

1 André Levi, "L'hédérité des fontes, La fonderie moderne," 1927, page 399. Extracted FOUNDRY TRADE JOURNAL, page 42, vol. xxxvii.

2 P. Bardenheuer and K. L. Zeyen, "Stahl und Eisen," 8 (1928), page 515.

cates or MnO and FeO in the slag, the carbon dissolved in the iron is partly eliminated in the hearth, and, as these new constituents are added to the iron, a saturation with carbon does not take place in the furnace. However, this saturation point possibly may be decreased during further cooling after the pig-iron is tapped. During tapping, the iron precipitates its graphite, which in consequence of its low specific gravity and size of the crystals, comes up to the surface. Recent investigations, carried out by A. Michel[3] at some German blast-furnace plants, have resulted in pig-iron to-day being produced at these plants in all cases in the hyper-eutectic condition. That means that the separation of graphite is controlled to take place in the liquid charge. The separation of graphite takes place in these qualities of iron along the liquidus line of the iron-carbon diagram, and should theoretically terminate there if the alloy is of the eutectic composition. However, under-cooling the charge causes a removal from this point, and probably in pig-iron there is no eutectic point at all, because it is not the true binary iron-carbon system. At elevated temperatures the charge partly as graphite. Again, the relative quantities of graphite and cementite cannot be accurately predetermined, as it is varied by several influences. During the cooling down of the pig-iron from the liquid state to low temperatures, graphite is separated at different ranges of temperature. Thus, if the pig-iron is hyper-eutectic, there will be large graphite aggregations, most of which comes up to the surface, but a small part is enclosed in the solidifying mass; there will be thin graphite during the passing from the solidification interval to the solid solution from the eutectic mixture, and, finally, fine graphite as the carbon is progressively separated out of the solid solution. Here it should be noticed that the separation of graphite out of the liquid mass only takes place if the iron cools down once. If such an iron is remelted, these large graphite aggregations rise to the surface and are not trapped in the mass during the solidification of the charge. If hyper-eutectic grey cast iron is melted in a crucible, kish may be clearly observed covering the surface of the charge. During the cooling down of such a charge, graphite is only separated and kinds of alloying elements, yet the relation between the analysis of the resultant alloy and its mechanical properties are still indeterminate. All that analysis shows is the weight of the graphite in a unit weight of the iron alloy. But it is not possible to find out by analysis how many lamellæ are contained in a unit volume of the alloy; the alignment of each individual nida; are certain sizes of these nidæ prevailing, and are the graphite nidæ equally distributed throughout the mass. The elucidation of these questions would give a more exact relation between the structure of any grey-iron alloy and its mechanical properties than is determined by the usual chemical analysis. These questions assume wide importance if, according to Levi, the size of the crystals is transmitted after remelting. The relationship between the size of grains of the graphite in a grey-iron alloy and its mechanical properties have been determined by experiment by Bardenheuer,[4] who controlled the size of graphite grains in his samples by modifying the rate of cooling. He cast different test-pieces of normal size with coarse-grained, very coarse-grained and very fine-grained

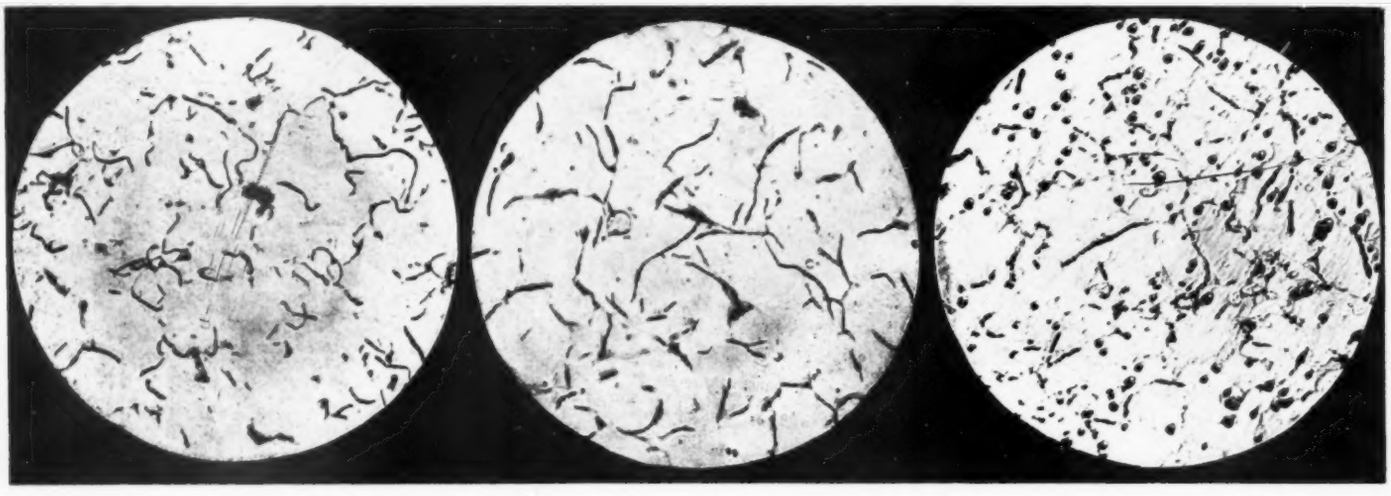


Fig. 5. Fig. 6. Fig. 7.

is thinly liquid, and the separated graphite rises to the surface; at lower temperatures the rising of the graphite is retarded, only a part of it reaching the surface; the other part remains in the charge until solidification, and so this graphite becomes a constituent of the alloy. These graphite crystals have their origin in the liquid charge, and so they increase without hindrance. They are visible in the structure as well-defined entities existing in roughly straight lines. In all alloys with a solidification interval there takes place first the separation of mixed crystals in hypo-eutectic alloys and of cementite in hyper-eutectic alloys, and, finally, with the complete solidification the separation of the eutectic mixture. The quantity of each constituent is definitely determined by the position of the alloy in the solidification diagram. At the same time, when the eutectic mixture is separated, in most of these alloys a certain part of graphite is formed, so that in the solid solution of the alloys the carbon exists partly as graphite. The quantity of graphite as against the quantity of combined carbon cannot be definitely determined in advance. Except from experience, several influences do regulate these quantities of graphite.

Influence of Remelting.

Finally, in the solid solution, the quantity of graphite can rise, because the solubility of the carbon decreases with lowering temperature, and the carbon is separated partly as carbide and when the temperature passes the solidus line in the diagram and again in the region of the solid solution.

Graphite and Combined Carbon Content Control.

The relative quantities of graphite and cementite cannot be predetermined exactly by reference to the eutectic and the solid solution lines, being dependent upon several diverse factors. Supposing that in iron-carbon alloys the iron-carbide system and the iron-graphite system are co-existing, this case is one of those where the constituents present are gravitating towards two different equilibra. The positions of both equilibria are known for the binary iron-carbon system. In these cases generally, whether neither the one equilibrium is attained nor the other, but usually a labile state is existing lying between the two equilibria. Through special influences, the position of this state can be removed to the one or the other side. The strongest influence has proved to be the rate of cooling, in such a manner that, with decreasing rate of cooling, the quantity of graphite increases. Besides this, other influences, such as that of the different normal constituents of grey-iron alloys, have been investigated in detail, so that it is possible to-day to give exact statements in this connection.

Analysis and Mechanical Properties.

Having established the possibility of influencing the degree of graphite separation, at least in a qualitative manner, by regulating the rate of cooling and by adding suitable quantities graphite separations. These tests showed that the finest graphite gave the best conditions for the production of the most favourable mechanical properties.

Controlling Graphitic Structure.

After these determinations it appears to be of importance to ascertain under what conditions the graphite is separated in fine or coarse grains and if it is possible to influence the separations arbitrarily. To ascertain these, the process of separating may be again considered. If the charge passes because of the lowering of the temperature from the liquid to the solid solution, the separation of the graphite takes place in the same manner as the crystallisation of any other liquid mass having constituents in solution. In a homogeneous charge existing in the liquid state, primarily during the cooling down, nuclei appear in the region of increasing speed of crystallisation growing into crystals. The size of these crystals depends upon the speed of growth, the period, the existence of neighbouring crystals of the same or a foreign kind, and the conditions of concentration of the liquid. Crystals of the same kind unite if their neighbouring position is favourable. If in hyper-eutectic alloys graphite separations are already present, they are the starting points of further crystallisation. If in eutectic alloys, within a small interval of temperature, the nuclei exist and at the same time the rate of crystallisation is high, crystals grow, the size of which depends

[3] A. Michel, "Stahl und Eisen," 47 (1927), page 696.

[4] Bardenheuer, "Stahl und Eisen," 7 (1927), page 857.

upon the number of nuclei, and if its degree of undercooling is low. However, if numerous nuclei appear later, when the rate of crystallisation is slow, the liquid charge is highly undercooled, there will be numerous small crystals. In these relations the influence of the rate of growth of the crystals and the number of the crystals on their size is clearly explained. The influence of time is also perceptible, the longer this period, that is, the passing from the liquid to the solid state, the more the crystals that can grow or unite with neighbouring crystals. The conditions of concentration also influence the amount and the number of the graphite separations, and the growth of the crystals is hampered the greater the quantity of the mixed crystals there is in the solidification interval. Moreover, the time of passing from liquid to solid diminishes with the increasing content of mixed crystals. If the composition of the alloy is not far from the eutectic concentration, then the graphite separations must become fine.

α and β Graphite.

The graphite in the solid solution is the result of the gradual transformation of the austenite into martensite and the consequent decrease of the solubility of carbon. The separation of the carbon from the solid solution gives partly cementite and partly graphite, and generally it spreads out reticularly in the alloy, probably favoured by the expansion of volume which is a characteristic of this transformation, and the graphite separations mainly originate in the nidæ of this network structure. The quality of this graphite differs from that separated primarily as well in its constitution as in its physical properties. W. A. Roth established that graphite in pig-iron is a modification which he calls β-graphite, and the graphite which is separated out from the solid solution differs from this, and is identified by him as α-graphite. Both modifications differ in their ignition temperatures and in their specific gravity.

Importance of Nuclei.

In the solidification of pig-iron, the number of mixed crystals and their extent depends upon the number of nuclei, which latter are influenced by certain inherent conditions. The number and size of austenite crystals especially depends upon the rate of cooling of the mass; if it is slow, a number of well-developed crystals will grow, but if it is rapid, however, a greater number of smaller crystals of irregular form grow. The graphite crystals, being separated during the solidification of the remaining liquid mass, will grow (according to Bardenheuer[5]) at every crystal face with about the same rate of crystallisation, assuming them to be separated, until near the solidification point, if liquid is still present. However, with an increased undercooling, remarkable differences in the growth from the single faces of the crystals are observed. The faces, having a greater rate of crystallisation, restrain the others which grow more slowly, the crystals having inferior facets because of retarded growth in one or two directions. In the first case, with slow cooling and slight under-cooling, the graphite crystals grow to rounded grains. In the second case, with a serious under-cooling and a higher rate of cooling, graphite crystals grow in the form of thin leaves of varying size. These small leaves surround the surface of the existing austenite crystals and have a twisted form, which in section is worm-like.

Situation Summarised.

The form and quantity of the graphite crystals in pig-iron can be differentiated in the following manner:—(1) Graphite in large straight plates (hyper-eutectic graphite) separated whilst the major portion of the mass is liquid; (2) graphite in compact rounded grains separated near the eutectic line if the rate of cooling is slow and the degree of under-cooling is slight; (3) graphite in thin leaves, with spirals corresponding to the surface of the austenite crystals, and separated in condition of under-cooling; (4) graphite in a very fine state and equally disseminated (eutectic graphite) separated if the constitution of the alloy is favourable; and (5) graphite in soft and porous flakes, often adjacent to the cementite, and separated from the solid solution during cooling.

Identification of Graphite Types.

These different kinds of graphite may be recognised on the surface of pig-iron microsection. However, they are not usually separated under their "favourable" conditions, and, therefore, all sorts of varieties and transitional states may be found; they are not always seen in their well-defined forms, and sometimes it may be difficult to recognise the kind of graphite, especially as quite often in iron alloys not merely one kind of graphite but several exist. For instance, K. Ishikawa has described two types of graphite in cast iron which he designated as platy graphite and graphite in whirl. The graphite in whirl, he says, is the most desirable kind for cast iron, because it has a moderate strength and its structure is very homogeneous throughout the whole casting. To produce this structure Ishikawa suggested a composition containing about 3.2 per cent C and 1.7 per cent. Si. This kind of graphite is identical with the graphite in thin leaves. M. Hamasumi[6] has studied the question of the origin of the graphite in whirl, with the result that this structure not always is assured even if the indications of Ishikawa are closely observed. So he supposes that there are still other influences operating, and he refers to a Paper of K. Honda and T. Murakami,[7] who stated that gas, especially carbon monoxide, plays a part in the separation of graphite. One of the results of Hamasumi is that there are two kinds of curly graphite, graphite in whirl and a worm-like* graphite. He says the one or the other is separated according to the rate of cooling. It may be seen by this that these authors already saw the possibility of recognising different kinds of graphite.

Now it would be very valuable to have a method of determination available by which the different kinds of graphite could be recognised and quantitatively determined. The analytic method for the determination of graphite only allows the evaluation of the total quantity of graphite contained in the alloy. All experiments to isolate the single crystals of graphite out of the alloy were abortive, and thus it has been impossible to measure the size and quantity of the crystals, or, for example, to derive a basis for the measurement of size, form and number of the crystals prevailing in the alloy. Dr. Franz Roll[8] determined the size and form of the graphite crystals by observing on the surface of a microsection some single lamellæ of graphite by measuring their size and position and after removing a thin layer remeasuring and so on until he ascertained the whole size of the crystal. As a result, he was able to determine by this method the space occupied by the graphite. This method may certainly throw light on this question, but it cannot generally be employed because it is too laborious.

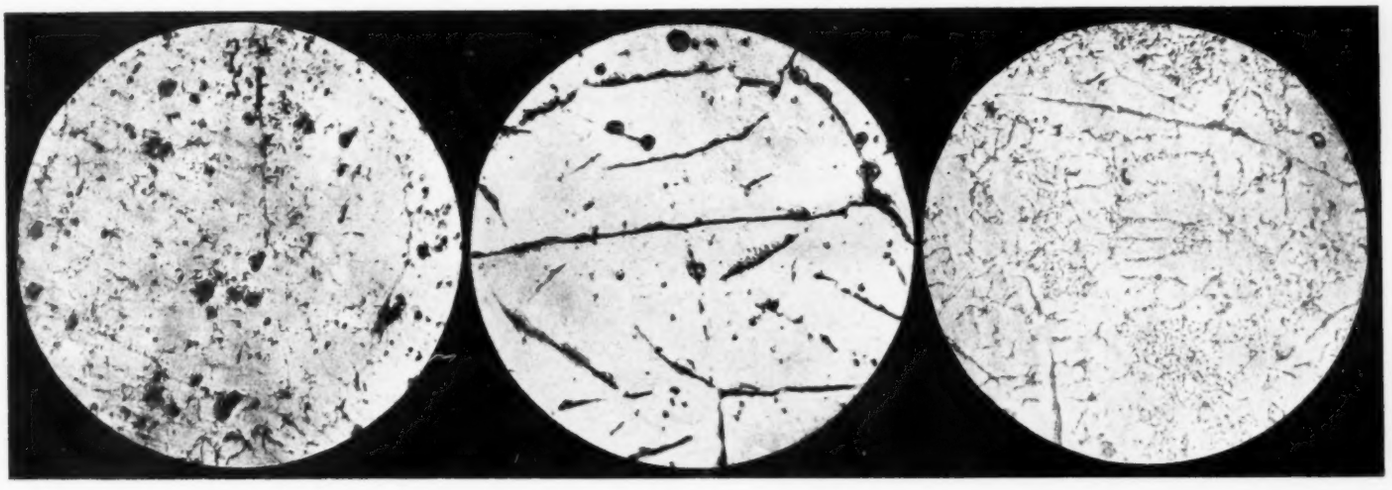


FIG. 8. FIG. 9. FIG. 10.

Experimental Evidence.

Therefore, an attempt had to be made to supply an explanation of the graphitic structure from its appearance under the microscope after the manner of Hamasumi. To make an experiment for recognising and determining the different kinds of graphite, it was first tried to make samples containing the graphite in specific well-defined forms, and this was done initially without considering the means which had to be employed.

Fig. 1† is a microsection showing well-defined platy graphite. This graphite interrupts the metallic structure of the alloy in an important manner, and it seems probable that it is separated when the mass, or most of it, is still liquid. This structure is obtained, as the

[5] Bardenheuer, "Stahl und Eisen," 47 (1927), page 861.

[6] M. Hamasumi, "Sc. Rep. Ser. I," vol. xiii, No. 2. See FOUNDRY TRADE JOURNAL, page 71, *et seq.*, vol. xxxii.

[7] K. Honda and T. Murakami, "Sc. Rep.," vol. x, No. 4.

[8] "Die Giesserei," 1928, page 1270.

* Kikume. Ed. FOUNDRY TRADE JOURNAL.

† All the microphotographs shown are magnified to 120 diameters and are unetched.

author's experiments have shown, if the iron cools down slowly under an argillaceous slag. The plates of graphite are larger and better defined as the rate of cooling is slow.

Fig. 2 illustrates a sample having the graphite in thin leaves. To obtain this structure a certain relationship between the composition of the alloy and the rate of cooling must be determined. It is not easy to state with existing knowledge an exact relation between these two factors.

Fig. 3 shows a microphotograph of an alloy of the same composition as Fig. 2, except that before casting 2 per cent. of copper was added. The graphite is present as thin, crooked leaves, but in addition there are numerous nidæ of graphite.

Fig. 4 shows the graphite in its finest distribution, that is, the graphite eutectic. To obtain this structure, a chemical composition of the alloy confined within certain limits is necessary, but personal experiments have shown that there are other obscure conditions to be taken into account.

After having created these standard forms, attention was next directed to the question as to whether the grey qualities of blast-furnace smelted pig-iron show a graphite formation on the surface of a microsection similar to those of the standard forms. A large number of samples from different blast-furnace plants were procured and examined, with the result that the majority did not permit of a rational classification. Whether several kinds of graphite were co-existing and thus presenting difficulty in deciding which was predominating, or whether the graphite was a transitional product. However, an exact characterisation was deemed to be useless. A certain number of specimens did show a characteristic structure, and a selection of these are included in later illustrations.

Interesting Structures from Diverse Sources.

Fig. 5 shows a micro of a sample of a Swedish charcoal pig-iron containing C 4.2, Si 0.64, and Mn 0.1 per cent. The graphite is in thin, curly leaves. A similar structure is shown in Fig. 6, which is a sample of pig-iron produced in a small blast furnace.

Fig. 7 illustrates a sample of an English pig-iron containing C 3.32, Si 3.28 and Mn 0.58 per cent. Besides graphite in thin leaves, globular graphite is also seen. A similar kind of structure is shown in Fig. 8, a pig-iron with Si 2.64 per cent., from a German plant. A noteworthy microsection showing platy graphite is reproduced in Fig. 9. Fig. 10 shows the structure of an Indian pig-iron with well-defined eutectic graphite.

Condition of Graphite and Transverse Strength.

No doubt the mechanical properties of these alloys are definitely dependent upon the type of graphite contained in the structure of the alloy. Platy graphite very largely interrupts the metallic continuity of the alloy, and samples with graphite of this type will have very low strength properties. The strength values increase with an increasing refinement and curliness of the graphite. As an illustration, some examples from practice may be cited. Test-bars, 650 mm. long by 30 mm. dia. (26 in. by 1.2 in.), were cast and tested in the usual manner. The first test-bar contained graphite in platy form, as shown in Fig. 11. This structure was obtained by melting the alloy under an argillaceous slag and cooling it down slowly. The second test-bar contained graphite in the form shown in Fig. 12, that is, in curly striæ. The structure of the third bar is shown in Fig. 13. It was obtained by a still slower cooling than previously. The striæ are thinner. The rate of cooling, which must be controlled to obtain these desirable thin striæ of graphite, depends upon the chemical composition, and must be found by experiment. The results of the test are set out in Table I.

The result of all these investigations is that often, in various qualities of grey pig-iron, a certain type of graphite prevails in the structure, and that the kind of graphite separation strongly influences the mechanical properties. If, now, as has been previously stated, a transmission of the properties of the pig-iron to the remelted cast iron can be postulated, full attention must be directed to the kind of graphite in pig-iron as well as in the cast iron itself. Normally, a poor structure in the original pig results in a very slightly improved structure in the cast iron using the normal every-day remelting processes. This explanation conforms with practice, that is, the qualities of grey pig-iron produced in various plants and of the same chemical composition sometimes give, after a remelting, a cast iron of varying qualities. It is the structure, especially the type of graphite in the pig-iron, which is the cause of these differences being not perceptible from the result of chemical analysis. In consequence the evaluation of the quality of pig-iron must include the type of graphite present.

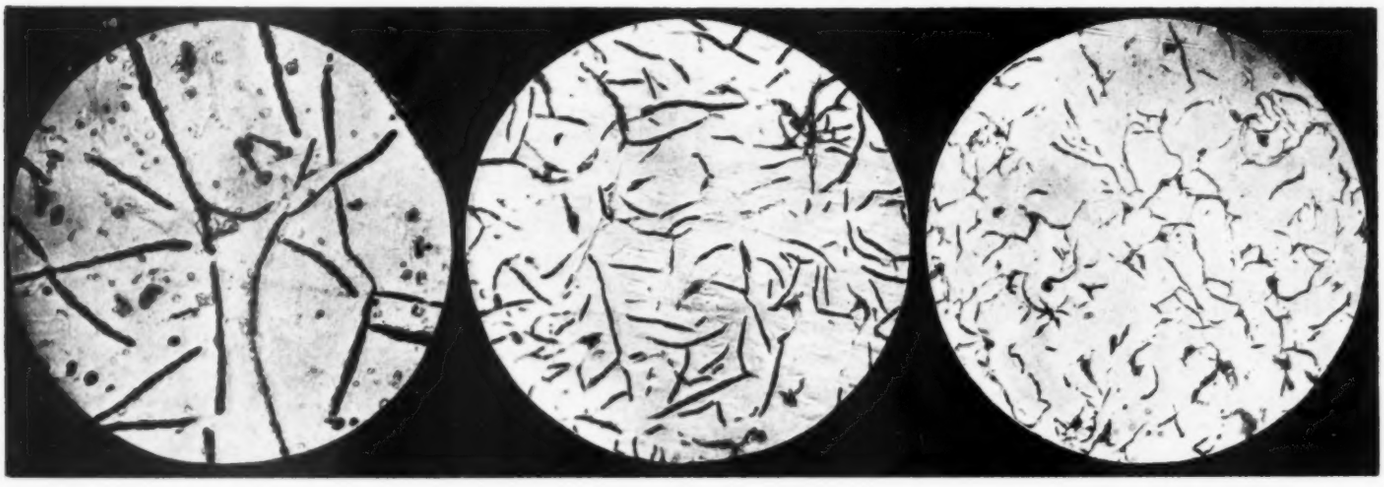


Fig. 11. Fig. 12. Fig. 13.

Table I.—*Influence of Type of Graphite on Mechanical Strength.*

Test-bar.	Type of graphite.	Deflection in mm.	Transverse strength in kgs. sq./mm.
1	Platy (Fig. 11) ..	17.5	23.5
2	Curly (Fig. 12) ..	12.1	42.0
3	Fine curly (Fig. 13)..	12.3	47.3

Result of Sequestration of Foundries.

When making pig-iron for foundry use, blast-furnace men not only have to ensure that they fulfil the desired chemical composition, but also to endeavour to produce a pig-iron with the most favourable structure for foundry purposes. No doubt, in blast-furnace practice, managers have several means at their disposal to influence the structure of the pig-iron, not only by regulating the speed of cooling of the pig-iron, but by certain measures in the furnace practice itself. As shown above, rate of crystallisation, the number of nuclei and degree of undercooling of the mass play a decisive part in the development of the structure, not only in regard to the graphite itself, but also for all other metallic crystals. No doubt, these influences have no constant value, but are governed by certain laws; for example, speed of cooling, number and kind of constituents, and perhaps others. Honda, as well as Bardenheuer, have stated that gas contained in the liquid charge plays a certain part during the crystallisation. Moreover, it seems evident that the kind and composition of the graphite influences these crystallisation processes. It is a fact, known to blast-furnace men, that pig-iron produced with a slag rich in lime is very coarse grained, whilst those made under a slag rich in silica is fine grained. It seems that an argillaceous slag also influences the structure of the alloy in a sense that platy graphite predominates. As experience shows that the fine curly graphite often occurs in pig-iron alloys produced in charcoal blast furnaces or in small furnaces, it seems probable that still other influences, such as the temperature of the blast, the temperature in the hearth or the period of the working of the charge, are important.

The experience that the quality of the pig-iron is not solely expressed by chemical analysis has long been well known when blast furnaces and foundries were a composite plant. This phase lost its force when, through the growth of industry, the sequestration of blast furnaces and foundries gradually took place. To-day, direct contact between pig-iron manufacture and the quality of cast iron must be re-established.

The training ship "Mars" has been sold to Messrs. Thos. W. Ward, Limited, Sheffield, and towed to Inverkeithing to be broken up. Messrs. Ward have also purchased the Canadian cruiser "Patriot" from the Dominion Government, and have successfully brought the vessel from Halifax across the Atlantic to the firm's shipbreaking yard at Briton Ferry.

The Grimesthorpe Foundry of the English Steel Corporation Limited, Sheffield.

In pre-war days, the Grimesthorpe foundry was devoted mainly to the production of heavy castings, such as required for rolling mills, forging presses, shipbuilding and the like. A certain tonnage was done in light castings, but no special facilities were provided in the foundry to cope with this class of work.

Following the termination of the war there was comparatively little business to be done in heavy castings for the engineering industries, and for the little available there was naturally very severe competition.

In order to meet the changed conditions and to produce the lighter castings more economically than was possible in a foundry designed especially for heavy work, it was determined to reconstruct the whole of the foundry in such a manner that whilst the old portion would still serve for the heavy castings, the extensions would provide in the most efficient manner for the manufacture of light and medium castings.

Obviously the efficiency of the modern foundry is that of its least efficient unit, assuming that the general layout is all that it should be. Let the auxiliaries be never so good, their efficiency may easily be negatived by comparatively minor details in their disposition, which by interference with the continuity of operations entails a serious addition to labour costs.

Determined to avail themselves of the latest word in equipment and layout, no details regarding the extensions were settled until careful studies had been made of the most modern methods in this country, in America and on the Continent. The Grimesthorpe foundry as it exists to-day is certainly the latest word in layout and equipment for a foundry capable of producing 200 tons of castings per week.

The light foundry is designed for the production of castings from 28 lbs. to 30 cwts., while the larger castings will be made in the old portion of the foundry, in which castings up to 170 tons or over can be made.

The light castings moulding bay is served oy two 5-ton and one 10-ton overhead cranes, and the closing bay by cranes of 25 tons, 20 tons, and two of 5 tons capacity.

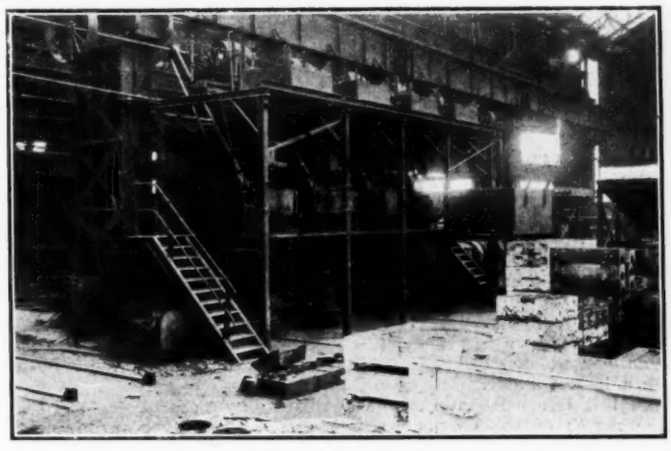
The moulding machines, arranged down one side of the building, comprise 4 Ajax, 8 Britannia and 2 hydraulic machines by the Universal System of Machine Moulding and Machinery Company, Limited. These last two machines are set apart for extensive repetition work, the remainder being for general service, and will take boxes up to 9 ft. square.

Sand-Handling Plant.

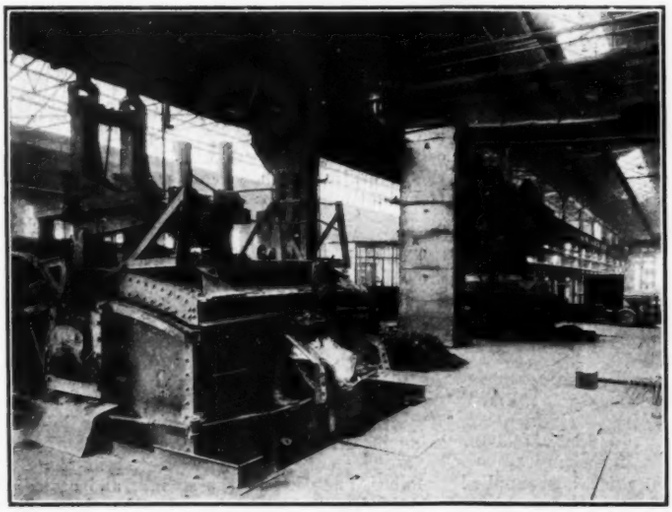
This is one of the most interesting features of the foundry, and in many respects it is unique. The facing-sand for the moulds is discharged from its bunker into bottom-emptying hopper-buckets. These are handled by one of the cranes and discharged into one of a series of hoppers which are placed between each pair of moulding machines; these hoppers have a capacity of about 3 tons, with discharge openings at knee height, so that stooping is reduced to a minimum. In order to appreciate the method of handling the backing sand, it is necessary to commence at the point where the moulds are knocked out. An iron grid extends along one side of the casting bay and this is served by what is nothing more or less than a miniature ingot-stripper of 2 tons capacity by the Wellman Smith Owen Engineering Corporation. The arms of the stripper pick up the boxes and drop them on the grid, whilst a ram is provided to deal with stickers. The stripper also carries a 1-ton lifting-magnet, by which the castings are loaded into the shop trucks.

The sand falling through the grid passes on to a steel plate conveyor. This delivers the sand to the boot of a bucket-elevator, by which the sand is raised and delivered into the screen above the sand-hopper. The over-material from the screen is delivered into trucks on the floor level. The through-sand is delivered on to a rubber belt running in a culvert across the casting and moulding bays. Two magnets are sus-

THE MOULDING BAY.



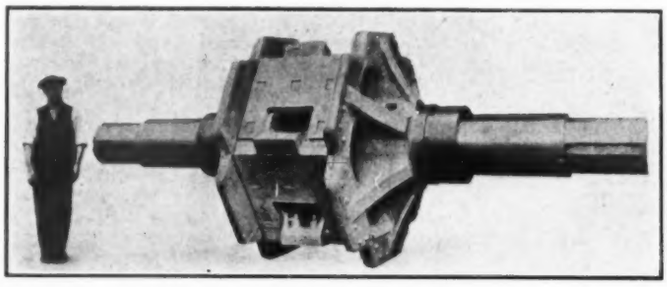
OIL SAND PLANT.



THE ELECTRIC-FURNACE STAGE.

THE CASTING BAY.

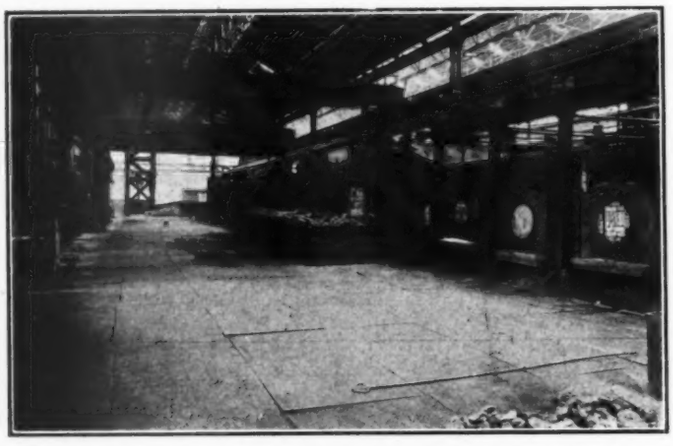
pended above the feed-end of the conveyor, a trapdoor being provided in the culvert at this point to enable gaggers, hooks, tramp iron, etc., intercepted by the magnets, being removed periodically. The band conveyor delivers to a bucket elevator by which the sand is transferred to the storage hopper, the capacity of which is equal to a four-hours' supply to the moulders. From this hopper the sand is delivered to a short band conveyor feeding a bucket-elevator which delivers to a reciprocating conveyor, actually a



A Hollow Tumbler Cast in One Piece. The Core is Removed through the Hole situated between the Ribs.

trough. Over the length of this trough a shaft extends upon which are mounted a series of paddles. These are held vertical in the forward direction, but swing about their axis on the return. This conveyor extends for the full length of the battery of moulding machines and is equal to delivering 10 tons per hour into the range of hoppers placed at the rear of the machines. The sand from the hoppers is delivered through a flap-controlled outlet on to the feed belt, which is driven through reduction gear by a 1½-h.p. motor. The motor, reduction gear and belt is a self-contained unit, bolted on to the mouth of the hopper, so that it is easily removable when necessary. This feeding apparatus is covered by patent.

Each moulding machine is served by a light jib crane, which conveys its mould into the centre of the bay to await removal into the drying stove.



The Siemens Stage.

Drying Stoves.

There are four drying stoves, laid out in two pairs; each stove is equipped with two thermo-couples and heated by an adaption of the August portable heater. The coke is fed to these by gravity from a hopper, which is served by the shop crane.

The drying stoves, served by bogies, are of the through type, the green moulds being drawn from the moulding bay side and the dry moulds withdrawn on the casting bay side by the shop crane working on a snatch block. The stove doors are constructed of Sil-o-cel cement, the efficiency of which was apparent at the time of our visit, as the doors were merely warm, whilst the internal temperature of the stoves was 550 deg. C.

Oil-Sand Core Mixing.

For the core-making, the incoming sand is passed through a Pneulec dryer into hopper buckets, which are lifted by the shop crane and discharged into the hoppers above the sand-mixers; of these there are four, by the Fordath Engineering Company. In these machines measurement is entirely automatic. The sand hopper terminates in an oblong box, which protrudes over the top of the mixing pan, and is provided with sliding panels at its feed and delivery ends, so that the quantity delivered is always a constant factor. The oil and water are measured in a graduated glass gauge, when they are mixed with a spinner, and the emulsion joins the sand in the pan. Glyso is very largely used.

All cores are hand-made, many being of quite exceptional size. In the core shop one saw rather an unusual application of the pneumatic hammer, such a tool, fitted with a ram head, being used for ramming. It is simple and certainly very efficient. The core shop is served with three pairs of stoves, miniatures of the stoves already described. The variation in the size of the cores makes a statement as to temperature control abortive, unless accompanied by much explanatory detail.

Melting Plant.

This consists of two 60-ton and one 20-ton open-hearth Siemens acid furnaces, one 6-ton "Fiat" and one 3-ton Greaves-Etchells electric furnaces, these last being employed to supply steel for intricate or specially high-grade castings.

Gas for the open-hearth furnaces is supplied by two of the latest-type Morgan gas machines, each of 3 tons per hour capacity; a noticeable feature of the machines are the exceptionally large dust-catchers. The machines are controlled by Arca regulators, whereby the steam pressure for blowing is governed by the gas pressure in the main. Steam for the blowing is raised in a Cochrane boiler, which is gas-fired; this boiler is provided with automatic feed and automatic gas regulation. These two gas machines have displaced fourteen producers of the old Morgan type, which were put into commission in 1906.

The stock bay is served by a 10-ton crane, which carries a 2-ton magnet. A noticeable feature of the charging arrangements is that the whole of the charging boxes are cast steel. One end of the stock bay is laid off for material for the electric furnaces. Metal is tapped into 15-ton ladles and taken to the casting floor on a Dewhurst manually-operated transporter.

The Fiat furnace, at the time of our visit, was out of commission, but the 3-ton Greaves-Etchell was doing excellent work. The roof lasts about 125 heats, whilst the hearth can be relied upon to exceed 1,000. The output for the week before Whitsuntide reached 32 charges, or, say,

The Sand Feeder.

100 tons, and this can be taken as typical of the best British practice. The consumption of electricity per ton of steel in the ladle, including that used for reheating after week-end stoppages and all other such jobs, is just under 800 units. The electrode consumption per ton of steel is 9.6 to 11.6 lbs. The Fiat furnace, too, has given very good service. A superficial glance at the Fiat installation gives the impression that, owing to the superstructure carrying the electrodes, much time would be taken up when replacing a worn roof. However, by a system of plugs for the cables and easily accessible bolts, the time for this operation is now not materially different from that required for the normal British design.

Dressing and Annealing.

The stripped castings are delivered by shop trucks on to rail grids at the end of the casting bay, where they are rough fettled, the heads and risers removed, in the main by the oxyacetylene process, the gases being piped from a central generating station. Rough fettled, the castings are placed on an incline, which feeds them into the annealing furnace. This furnace, built by Wincott, of Sheffield, is of particular interest, being of the three-chamber gas-fired continuous type. The castings are preheated in the first chamber, annealed in the second, and cooled in the third. The heat given out by the cooling castings preheats the air for combustion in the

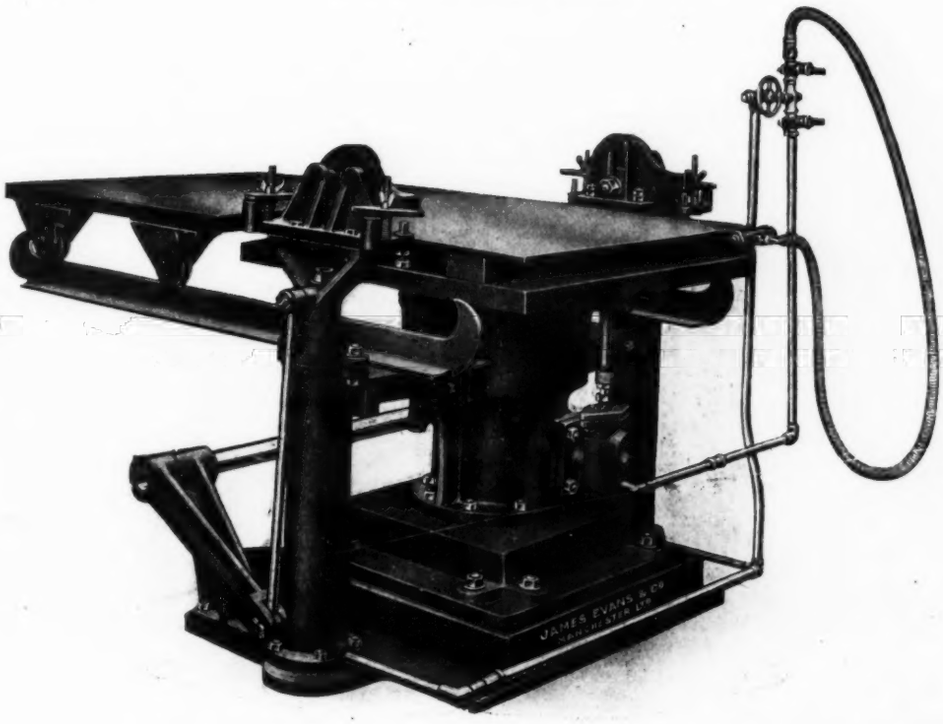
TYPE "C"

JAR RAM MOULDING MACHINE

with Turnover Pattern Plate.

For Pneumatic Power.

TWO MACHINES IN ONE.



UNSKILLED LABOUR ONLY REQUIRED.

The above machine illustrates a Jar Ram Machine with Turnover Pattern Plate which can also be used for Stripping Plate Work.

The machine has been designed to combine the two distinct features above mentioned, and is practically two machines in one, equally suitable for steel, iron, etc.

The machine as illustrated is arranged for work that requires turning over, such as steel moulding. And while the turnover arrangements are intended for general repetition work, by detaching the turnover plate from the trunnion brackets the machine can be used for stripping plate work by attaching the stripping plate to the trunnion brackets. Or, on the other hand, by removing the trunnion brackets as well, the table can be used for jolting general jobbing work.

A very important feature of the machine is the simplicity with which the intensity of the Jolt can be regulated when the operator has become accustomed to the use of the machine, which takes but an hour or so. The valves all being on the exterior of the machine are easily accessible, and there is an adjustable arrangement that will allow the jolt to be varied between 1½ in. to below ¼ in. This being done without disturbing any part of the machine.

The machine is supplied with Withdrawal Carriage, Vibrator, and Blow-off Nozzle complete. It is substantially constructed to stand heavy wear and tear, and requires a minimum amount of skill to operate.

Another important feature of the machine is in the arrangement of the hard wood anvil block for receiving the shock. The blocks being carried well down the machine in a specially designed annular chamber give considerable relief to the foundations. It also provides against the possibility of fracturing the jolting table. Pitch pine blocks are also inserted between the foundation plate and the machine bedplate to assist in the relief on the foundations, and these features considerably improve the working advantages of the machine.

IT IS ALSO ENTIRELY OF BRITISH DESIGN AND MANUFACTURE.

JAMES EVANS & CO. (M/c) LTD.

Britannia Works, BLACKFRIARS, MANCHESTER.

annealing chamber, and the hot gases discharged from the annealing chamber supply the heat for preheating in the first chamber.

Each of the three chambers are 20 ft. long by 8 ft. wide by 6 ft. high.

There are separate gas supplies to the preheating and annealing chambers, an arrangement that makes it possible to use the preheating chamber as an "in" and "out" furnace. Obviously also should it be necessary at any time to force the furnace, gas can be burnt in the preheating chamber to supplement the waste heat coming over from the annealing chamber. Normally the preheating chamber is not under gas.

In the annealing chamber gas is admitted continuously through six ports on either side of the chamber. The ports are disposed vertically, and as the three out-takes are at bogie level the chamber must always be flooded with gas, which ensures remarkably uniform heating throughout the chamber; in point of fact, the temperatures taken at the four corners were within 5 degrees of constant.

The six doors are controlled in two groups of three by push button. The doors are raised by chains, which are driven by a 5-h.p. motor, which runs at 1,000 r.p.m., the ratio of reduction being 150 to 1. The motors and gearing are mounted at diagonal corners on the top of the furnace structure.

The furnace chimney called for the exercise of some ingenuity: it had to be carried through a double crane track, and in order to obtain the necessary area this portion was made rectangular; 5 ft. 8 in. by 13½ in., connected with a conical piece to the chimney proper, which is 2 ft. 6 in. in dia.; the total height of the chimney is 53 ft.

After annealing the castings are sand-blasted in one of the various plants, which include Tilghman, Guttmann and rotary-table types. In the fettling shop there are a number of grinding wheels with peripheral speeds of 9,000 ft. per min.

At the time of our visit we were impressed by a large hollow casting, which was being fettled. By courtesy of the management, this has been specially photographed for us. Foundrymen will realise the difficulty of getting the gases away from such a large body of totally-enclosed sand through the four small apertures indicated. Naturally, oil-sand cores are used. Mr. Carter, the foundry manager, is something of a pioneer in the utilisation of oil sand for large steel castings, and some of the moulds for large manganese-steel castings are made in their entirety from this mixture. By collaboration with the research department, the percentage of oil used has been gradually diminished until 3 per cent. has been achieved.

The skin on the castings made in the Grimesthorpe foundry is particularly good. For the ordinary dry-sand work "Yorkshire" sand is used, whilst for some work a relatively new production, equal parts of Leighton Buzzard, Hinckley and old sand, is being used.

The production of a steel foundry of this character is not easily visualised by the average foundryman, as he is unfamiliar with its manufactures. To those who are intimate with this class of work the daily production from one machine of four magnet yokes and four manganese-steel brackets of large dimensions by one moulder and a helper will be deemed an excellent achievement.

Finally, we wish gratefully to acknowledge the collaboration of Mr. C. L. Mason and his staff in the preparation of this article.

One of the plate mills at the Malleable Works at Stockton of the South Durham Steel and Iron Company, Limited, was restarted last Monday.

Altogether 31 vessels, aggregating 48,740 tons, were launched from Clyde shipyards in June, making a total for the half-year of 119 vessels of 285,000 tons.

Some Unusual "Patterns."

High up in the vaulting of the choir of Winchester Cathedral are many bosses carved in the highest relief, and richly coloured and gilded. They were carved shortly after the year 1500. These bosses are most of them of immense size, many being upwards of 3 ft. across, the largest perhaps 5 ft. and the smallest not less than 2 ft., that they may be clearly visible to the congregation beneath. The bosses are in no sense "patterns" from the foundryman's point of view, but are representations of actual objects carved in wood. So deeply, however, are they cut out, and in such high relief, that many of them, with but little alteration, could actually serve as patterns in a foundry.

The designs show us all sorts of subjects, and representing, as some of them do, various articles connected with the iron industry 400 years ago, and showing us copies in wood of various metal objects which were in common daily and even household use at that time, a short description of one or two of these carvings may not be without interest. One boss shows a mediæval lantern, another a metal vase, and so forth.

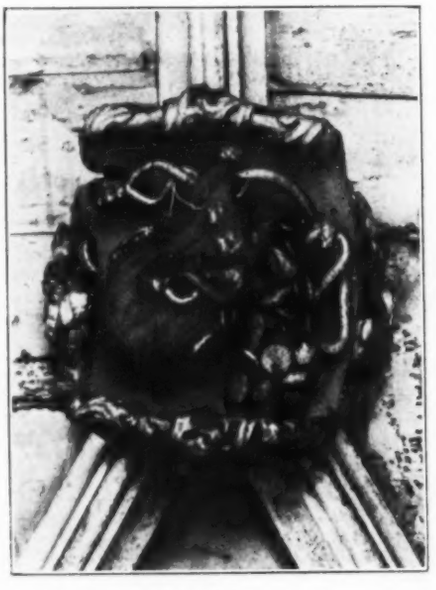


Fig. 1.

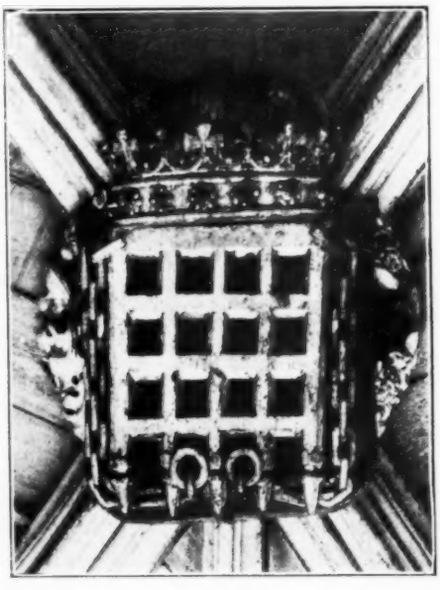


Fig. 2.

By the kindness of Mr. Cave, of Petersfield, by whom attention was first properly directed to these bosses, we are able to reproduce two of his photographs.

The boss (Fig. 1) has for its design a scriptural subject, for on it is carved the bag of Judas with the 30 pieces of silver. The bag is shown as so far inclining sideways that a torrent of the coins is escaping. The bag itself is the common mediæval gypciere or bag suspended from the waist. Such bags consist of an iron frame of more or less elaborate design from which depends the stuff or leather bag proper. The iron frame was in two pieces connected at either end by hinges, so that it could be opened to receive or disgorge its contents.

Fig. 2 shows a boss upon which a portcullis and its chains are carved. Chains have been constantly made in ironworks for centuries, and as few ancient examples exist to-day it is of interest to see a representation of the sort of chain which was a common object to those living in the days of Henry the Seventh. The picture shows one of the heavier chains in common use at that time. Various others of these fine bosses show in a most realistic way and on an enormous scale the appearance of different metal articles. One represents a spear, others dishes, flagons, chalices, nails, hammers, pincers, portable braziers, spice-pots and crowns.

Catalogues Received.

Flooring.—We have received from the Shipwright Flooring & Engineering Company, Limited, a four-page leaflet, which illustrates and describes a novel and common-sense system of floor construction. Foundrymen will appreciate the sound and fireproof qualities of the flooring described when they learn that Fosalsil (Moler) is embodied in it. Whilst strength is certainly claimed for this flooring, which should recommend it for the works departments, such as shops devoted to the cleaning of castings, welding, patternmaking, heat treatment and the like, as well as for blocks of offices.

Plastic Fire Cement.—Messrs. J. H. Sankey & Son, Limited, of Essex Wharf, Canning Town, London, E.16., are using a folder to call attention to hard-setting qualities of Pyruma fire cement. They reprint a letter which stresses from a customer who found that a temporary bridge had set so hard, on account of using Pyruma, that they had difficulty in demolishing it, but prefer it for permanent structures. It is certainly a striking example of modern constructive publicity.

Power Drives.—The Morse Chain Company, Limited, of Letchworth, Herts, has sent us a 24-page well-illustrated brochure, outlining the advantages and applications of chain drive. As the booklet is almost entirely devoted to the textile industry it will no doubt be of interest for the large numbers of foundries catering for that section of engineering.

French Engineers' Tour of Great Britain.

A party of sixty members of the French Society of Engineers, accompanied by their wives and daughters, arrived in London on June 29 for a week's tour of Great Britain. Mr. A. E. Moutier, the president, is in charge of the party, and the engineers will study at first hand various phases of British engineering activities. Amongst the various works they intend to visit are the L.M.S. Railway works at Derby, several foundries at Sheffield, and the engineering works at Glasgow of the Fairfield Shipbuilding Company and Messrs. Babcock & Wilcox.

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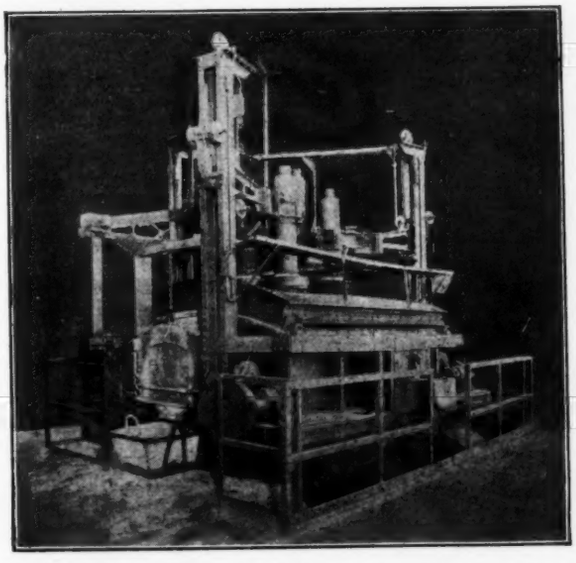

NON-FERROUS METAL MELTING ELECTRIC FURNACES

SINGLE, TWO, or THREE PHASE.

CONTRACTORS TO HOME AND FOREIGN GOVERNMENTS.

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Lancaster Street, SHEFFIELD.

Fig. 4 shows the Doty apparatus for controlling the strength of the moulding-sand. This test takes place before the moulds are dried in the stove. The samples have the following dimensions: 30 × 30 mm.², 250 mm. long, weight of B: 750 grams. The value of A (being the point at which the bar will break) depends more or less on the oil content and on the fineness of the sand. For instance, 300 litres of sand, with 5, 6½, 8 and 9½ litres of linseed oil, the test-pieces broke, and when made of river-sand, 73, 95, 103, 122 mm., and when made of sea-sand, 95, 118, 143, 147 mm. respectively. Room temperature also has an important influence.

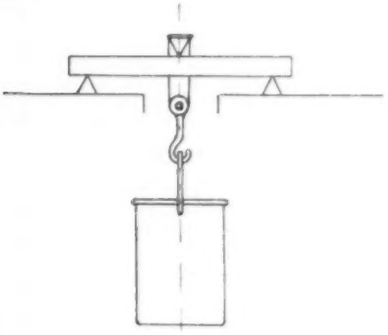

Fig. 5.

Fig. 5 is an ordinary transverse apparatus. The distance between the supports is 200 mm., whilst the test-pieces have a diameter of 30 × 30 mm., and in the middle of the sample a small bucket is suspended into which water is poured until the sample breaks, and then the quantity of water is weighed. The test-pieces are dried on a temperature between 150 and 175 deg. C. The following results have been obtained: 300 litres of sand with 5, 6½, 8, 9½ and 11 litres of linseed oil broke with 13,500, 20,000, 25,700, 27,800 and 32,400 grams of water respectively.

CONTRIBUTION.

Mr. F. Hudson wrote: This Paper contained interesting work relative to the effect of black-washing mould-surfaces upon permeability, and a contention as to the theory of permeability. Unfortunately the figures shown by Mr. Van Aarst in Table II are not of general application. To exemplify this fact, he would particularly like to draw attention to the appended table of permeability test figures as found by himself during a study of a similar question. It will be noticed that the large differences in permeability found on the same core before and after blacking by Mr. Van Aarst do not exist when tested in a different manner. The test results shown in Table A were obtained by drawing 600 ccs. of air through a 1-in. dia. core as shown in Fig. A. They show that the thickness of the black-wash coating, together with the composition of the black-wash used, will vary the permeability figure, but at the same time little variation is probable if these two factors are controlled.

In regard to the use of synthetic sands for loam moulding, this has been more or less standard practice on the Clyde for many years. A coarse river-bottom sand, not unlike gravel, is heavily milled with or without slight fireclay addition, no sawdust, cow-hair, coke-dust or horse-manure being added whatsoever. Approximately 17 per cent. of water is required to obtain the condition for strickling or working. Such a mixture gives a transverse test of 151 ozs. per sq. in. with a permeability of 3,142 seconds. On the other hand, the practice on the Tyne is to use a mixture of Erith loam, black sand, horse-manure, sawdust, etc., milled with about 25 per cent. water and giving a transverse test of 511 ozs. per sq. in., with a permeability figure of 1,230 seconds. So far as test results go the Tyne mixture is certainly the better, although in practice excellent results are obtained from each.

The Clyde sand is nearly 2½ times more dense than the Tyne practice, but the increased permeability of the Tyne sand is offset by the extra amount of gas generated on casting through decomposition of the organic matter added.

It would appear that the degree of permeability required in moulding-sands is determined by the amount of gas generated at casting, together with the ease of removing displaced air from the mould. If no gas is generated and the displaced air has easy means of escape, then permeability in a moulding-sand is a very minor consideration indeed. In closing, he thanked Mr. Van Aarst for drawing attention to a foundry point which is often overlooked in the study of moulding-sands.

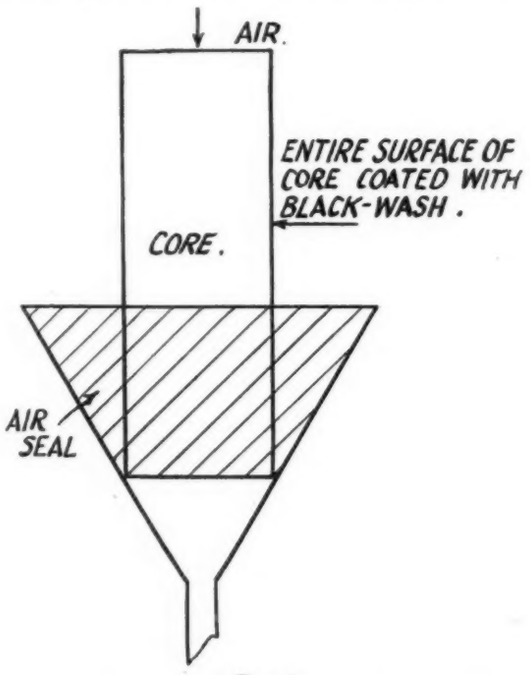

Fig. A.

Table A.—*Effect of Blacking on Cores. (Permeability.)*

Type of core.	Coating.	Thickness of coating in Ins.	Perm. in secs.
3 per cent. linseed oil and sea sand.	None	—	38
	None	—	37
	None	—	38
	Blacking (clay wash bond) ..	$\frac{1}{32}$ approx.	45
	„ (clay wash bond) ..	$\frac{1}{32}$ „	45
	„ (core gum bond) ..	$\frac{1}{32}$ „	75
	„ „ „	$\frac{1}{16}$ „	106
Glenfield & Kennedy oil core sand.	None	—	47
8 parts sea sand.	None	—	44
1 „ Wormit Red.			
2½ per cent. compound S.S.	Blacking (clay wash bond) ..	$\frac{1}{64}$ approx.	47
2½ „ „ 444.	„ (core gum bond) ..	$\frac{1}{64}$ „	47
Drysand cores.	None	—	205
	None	—	263
	Blacking (clay wash bond) ..	$\frac{1}{64}$ to $\frac{1}{32}$ approx.	207
	„ „ „ ..	$\frac{1}{64}$ to $\frac{1}{32}$ approx.	300
Loam.	None	—	3,324
(Irvine river bottom sand milled for ½ hour.)	None	—	2,960
	Blacking (clay wash bond) ..	$\frac{1}{32}$ approx.	3,616
	„ „ „ ..	$\frac{1}{32}$ „	2,426

Methods of Testing Cast Iron.

(*Continued from page* 21.)

what is necessary commercially. Like the shearing machine, the Guillery static transverse machine is very convenient in use: its dimensions are 225 × 120 × 80 mm. and its weight about 5 kg. The test takes a few minutes, and the constants required can be rapidly and easily read, while the machining of the test-piece is quick and inexpensive owing to its small dimensions.

The static transverse test in this form, therefore, possesses in the highest degree all the qualities required for a commercial test: economy, rapidity, simplicity and precision, and it is used in routine work without the least difficulty. It is now proposed to reply to the objections raised to the transverse test on a bar measuring 8 × 10 × 35 mm.

(To be continued.)

The works of the North British Locomotive Company, Limited, will close down for the Fair holidays at noon on July 11, and resume again on July 29.

F.T.J. 11 7 29

ALUMINIUM FOUNDRY DATA

ALUMINIUM CASTING ALLOYS

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The British Aluminium Company's publications (four of which are mentioned here) are issued as general propaganda for ALUMINIUM *and* LIGHT ALLOYS. *You can ask for them freely without obligation. The British Aluminium Co., Ltd., Adelaide House, King William Street, London, E.C.4.*

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Trade Talk.

THE BUSINESS of Messrs. Toope & Son, brass founders and general engineers, has been transferred from Frankfort Lane to 11, Vauxhall Street, Plymouth.

AN OUTBREAK OF FIRE occurred in a laboratory of the Royal Technical College, Glasgow, on July 5. The damage to chemicals and instruments is estimated at some thousands of pounds.

MESSRS. HEAD, WRIGHTON & COMPANY, LIMITED, Thornaby-on-Tees, have secured an order for the erection of an additional blast furnace for the Stanton Ironworks Company, Limited, Nottingham.

MR. L. H. SUTTON, a director of Bever, Dorling & Company, Limited, engineers and brass- and iron-founders, of Bowling Ironworks, Bradford, has been granted patent rights for an invention of a table for a tea-rolling machine.

BRITISH INSULATED CABLES, LIMITED, Prescot, Lancs, have recently received orders for approximately 10 miles of super-tension cable from overseas buyers, and for 500 miles of steel-cored aluminium strand for use on the English grid schemes.

THE IMPORTS of foreign iron ore at the Prince of Wales Dock, Workington, for the quarter ended June 30 amounted to 51,400 tons, against 35,300 tons in the previous three months and 23,000 tons in the corresponding period of last year. The ore imports for the first half of the year have amounted to 86,700 tons.

AN OUTBREAK OF FIRE occurred recently at the works of Messrs. Loudon Bros., Limited, Thorn, Johnstone. A large patternshop and store containing many valuable patterns was completely gutted, but the West Renfrewshire Fire Brigade succeeded in confining the outbreak and saving adjacent property.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Glasgow, have received orders for 25 six-wheeled-coupled tank locomotives for the Great Western Railway, and also for four new standard XB 4-6-2 type and five new standard XD 4-8-2 locomotives for the Nizams Guaranteed State Railways, India.

MESSRS. LITHGOWS, LIMITED, Port Glasgow, launched recently from their Kingston yard the screw steamer "Knight of St. George," which they have built to the order of the Newport-Normandy Line (Pardoe Thomas & Company, Limited), Newport, Mon. It is of the two-deck type for carrying general cargo.

THE ALUMINIUM PLANT AND VESSEL COMPANY, LIMITED, of Point Pleasant, Wandsworth, London, S.W., is extending its works by the addition of a foundry in which aluminium and gun-metal castings will be made. The announcement, not made in our columns, that the company proposed building at Twickenham is incorrect.

THE NEW coasting steamer "Saint Kearan," of 800 tons, built by Messrs. Scott & Sons, Bowling, to the order of Messrs. J. & A. Gardner & Company, Limited, Glasgow, ran successful trials on the Clyde recently. The triple-expansion engines, boilers and auxiliaries were supplied and fitted by Messrs. Aitchison Blair, Limited, Clydebank.

CONTRACTS FOR five vessels may benefit Clyde shipbuilders in the near future. Messrs. David MacBrayne, Limited, are about to place orders for three of the five vessels which they have undertaken to build to strengthen their service in the West of Scotland, but the yards have not been announced yet. A fruit-carrier will be built at Govan for Messrs. Elders & Fyfe, Limited.

IN A COMMUNICATION to the Press on his departure after a visit to this country, Mr. N. D. Koniukhoff (President of the Machine-Technical Syndicate of the U.S.S.R.) states that, after visiting various works in this country, he has had an opportunity of satisfying himself as to the high quality and workmanship of the goods produced and the efficiency of the technical management.

MESSRS. BARCLAY, CURLE & COMPANY, LIMITED, have launched from their Clydeholm shipyard, Whiteinch, Glasgow, the steam-driven tanker "Beaufort," built to the order of Messrs. Biorn Biornstad & Company, Norway. The vessel is designed for carrying oil in bulk, and is built to Lloyd's highest class on the longitudinal system of framing. The deadweight capacity is 8,000 tons on a draft of 24 ft. 9 in.

MESSRS. JOHN G. STEIN & COMPANY, LIMITED, Castlecary Brick Works, have presented a new bowling green and pavilion for the use of their employees at Castlecary. The green and club-house, which is situated at Allandale village, near Bonnybridge, is built on the site of the old Roman wall which passes through Stirlingshire. Mrs. John G. Stein, Millfield, Polmont, who performed the opening ceremony at the green, was presented with an electric reading-lamp from the contractors and a silver jack from members of the newly-constituted club.

THE BURNS AND LAIRD LINES, LIMITED, have introduced some interesting cargo-handling plant at their Broomielaw berth, Glasgow, from which the steamers depart for Belfast. The plant consists of three electric transporting cranes, two of them capable of lifting two tons, and the third of five tons lifting capacity. These are stated to be the first of their kind supplied to any dock in Scotland or England, and they were built by Messrs. Alexander Chaplin & Company, of Govan. They were inspected and passed by Mr. S. N. O'Neil, mechanical engineer of the Coast Lines, Limited, London.

THE GRINDING AND PULVERISING OFFICES of International Combustion, Limited, 11, Southampton Row, London, W.C.1, report that orders have been received recently for the following equipment:—For England: One 3-ft. by 5-ft. one-surface Hummer electric screen, for screening dry granite. For France: Six Impax pulverisers, for grinding coal; two 5-ft. by 22-in. Hardinge mills, for grinding soft sandstone; one 2-ft. by 8-in. Hardinge mill, for experimental purposes; four Raymond pulverisers, for grinding sulphate of lime; and one Raymond pulveriser, for grinding litharge. For Belgium: One three-roller Raymond mill, for grinding lithopone. For South Africa: One Raymond pulveriser, for pulverising fuel.

THE DIRECTORS of the N.C. Metal Company, Limited, have issued a circular with their report for 1928 dealing with the position of the company since the end of the accounting period. The exploitation of the rights belonging to the company is, it is stated, being steadily proceeded with. The licences for the manufacture of zinc in the British Isles, the Irish Free State, France, Spain and Portugal have been acquired by the Zinc Manufacturing Company, Limited, in which the N.C. Company has a substantial holding. The Zinc Manufacturing Company is expected to produce 50,000 tons in its second year. The ultimate production aimed at is 150,000 tons per annum. Further negotiations for the disposal of the rest of the European rights covering a production of over 400,000 tons per annum are at an advanced stage. The application of the process to the extraction of tin is to be proved on a commercial scale. Messrs. Stewarts & Lloyds, Limited, who hold a controlling interest in the company, are expected to have their complete plant operating during this month.

MESSRS. HARLAND & WOLFF, LIMITED, have launched from their Govan shipyard the twin-screw motor passenger and cargo vessel "Llangibby Castle," built for the Union-Castle Mail Steamship Company, Limited. The vessel is primarily intended for the company's service on the East Coast of Africa, via the Suez Canal, serving the Colonies of Kenya and Tanganyika, as well as Zanzibar, Beira and other places. The principal dimensions of the vessel are:—Length, 485 ft.; breadth, 66 ft.; depth, 33 ft. 6 in.; and gross tonnage, 12,160. The propelling machinery consists of two sets of single-acting Diesel engines of the Harland B. and W. type. Each main engine is direct-coupled to a propeller, and is of the eight-cylinder type, having a three-stage air compressor mounted at the forward end and driven off an extension of the crank shaft to supply the necessary air for fuel injection. The auxiliary power is supplied by three Diesel generating sets. Each engine has six cylinders, and is fitted with an extra large compressor for supplying air to the manœuvring air reservoirs.

THE FEDERATION OF BRITISH INDUSTRIES has suggested a number of points which the Economic Mission to Argentina and Brazil might discuss with the responsible authorities in the countries visited. The subjects suggested include the simplification of the Brazilian tariff, the operation of the laws of bankruptcy, the incidence of Customs House fines, procrastination in payments by national Treasuries, simplification of Consular invoices, passport regulations, bankruptcy laws, port congestion, and delay in clearing goods from Customs Houses. The Mission, which will leave this country on August 2, will be headed by Lord D'Abernon, the other members being Sir William Clare Lees (representing the textile industry), Mr. G. E. Rowland (engineering industries), and Mr. Jurian Piggott (iron and steel). The Mission will be accompanied by Mr. H. Chalkley, Commercial Counsellor to the British Embassy in Argentina, and will have as secretary Mr. H. W. Wiswould, of the Department of Overseas Trade.

Personal.

MR. F. SEYMOUR WHALLEY, general manager of the Vulcan Foundry, Limited, of Newton-le-Willows, locomotive builders, has been elected to a seat on the board and has been appointed managing director.

MR. C. A. VALENTINE, J.P., has, for reasons of health, tendered his resignation to the United Steel Companies, Limited, after holding for 23 years the appointment of chief engineer at the Oldside Ironworks, Workington.

SIR CECIL BUDD, who retired from the chairmanship of the London Metal Exchange last December, was presented recently with an illuminated album containing the signature of each member of the Exchange, as a mark of appreciation of his services during 27 years of office.

MR. R. GREENWOOD, of Derby, has tendered his resignation as general manager and director of the Combustion Engineering, Limited, Sinfield Lane, on having secured an appointment in the Sir W. G. Armstrong, Whitworth Corporation. Mr. Greenwood will not be leaving Derby until the end of September.

MR. GEORGE H. WRIGHT has been appointed general manager of the marine engineering works of Messrs. Swan, Hunter & Wigham Richardson, Limited, Wallsend-on-Tyne. Mr. Wright has lately been carrying on a consulting practice in Liverpool. Previously he was with Messrs. Cammell Laird & Company, Limited.

Wills.

NEWTON, J., chairman of Messrs. Billingtons & Newton, Limited, engineers and brassfounders, Stoke-on-Trent ... £39,041

Obituary.

MR. M. J. HABERSHON, a former director of Messrs. J. J. Habershon & Sons, Limited, steel rollers and founders, of Rotherham, died recently in his 74th year.

MR. T. H. MUXLOW, a director of Messrs. R. & J. Smith Brothers, Limited, iron, steel and metal merchants, of Bridge Street, Sheffield, died on Saturday, June 29. Mr. Muxlow had been connected with the firm for nearly forty years. He was formerly general manager, and became a director in 1920.

Company News.

Andrews Toledo, Limited.—A scheme of reconstituting another well-known Sheffield steel company has recently taken place by the formation of Andrews Toledo, Limited, which has taken over the works and assets as a going concern as from November 3, 1928, of the old-established firm of Jno. Hy. Andrew & Company, Limited. The capital of the new concern will be the same as before, viz., £300,000, and the board will comprise Messrs. J. F. Parker (chairman), G. St. J. Strutt, C.B.E., and Engr. Vice-Admiral Sir George Goodwin, K.C.B., LL.D. The company, which manufactures all classes of high-grade steels for tools for the motor-car and aircraft industries, for mining drills and wire rods, are immediately embarking upon a policy of modernising the various departments of the Toledo Steel Works at Sheffield.

New Companies.

Edwin Preston, Limited, Park Lane, Kidderminster.—Capital £10,000. Brass and iron founders. Directors: G. Preston and J. J. Briggs.

W. E. Martin, Limited, 17, Claremont Road, Hockley, Birmingham.—Capital £5,000. Rollers of metal, etc. Directors: W. E. Martin and Mrs. S. Martin.

Harrison & Company (Steel Stockholders), Limited, 6, Imperial Buildings, Oxford Road, Manchester.—Capital £5,000 in £1 shares. Directors: S. B. K. Harrison, E. G. Hutton and E. Bloor.

Andrews Toledo, Limited, Toledo Steelworks, Sheffield.—Capital £300,000 in 150,000 7 per cent. cumulative preference shares of £1 and 300,000 ordinary shares of 10s., to adopt an agreement for the acquisition of the business carried on by Jno. Hy. Andrew & Company, Limited, including the registered trade-mark "Toledo."

TRADE MARK.

"SERVICE BCM/GX FIRST"

"SANDS MAY COME
and
SANDS MAY GO"
but
"YORKSHIRE SAND"
GOES ON FOR EVER!

"YORKSHIRE SAND" THE STEELMOULDER'S FRIEND IS BETTER THAN EVER.

New and Scientific Mixing Processes have recently been perfected and installed, and our works equipped with Milling plant of the most efficient type, specially made for the work of sand preparation.

UNLIKE BELGIAN SANDS

—one thing to-day and another to-morrow—"Yorkshire Sand" does not vary in either grain size or percentage of bond and it is absolutely free from stones and lumps of clay,

AND

IT IS CHEAPER IN USE THAN ANY FOREIGN SAND.

The whole country is suffering from unemployment due principally to the unrestricted importation of unnecessary foreign goods—why not nail your colours to the mast and adopt the slogan—

"BUY BRITISH STEEL CASTINGS AND BRITISH SANDS!"

If the proposition presents any difficulty, send for us to talk it over and we will undertake to meet your reasonable views. If you use foreign sand, you can't legitimately complain of engineers using foreign castings.

We don't sell foreign castings and deprive you of work. We support British Institutions and trade and technical associations. We live here and pay British rates and taxes. We help to buy your output.

We don't ask for orders for 500-ton lots (payment against B/L), we sell in truck loads and wait for our money—sometimes three or four months (sometimes we never get it at all). We are always here at the end of a wire for advice, help or support. If you receive from us any goods you don't like—send them back.

We give prompt delivery of Yorkshire Sand and every ton lot of it you buy finds work for Englishmen and Scotsmen and helps to improve your own business by circulating more money in the country, and reducing the amount sent abroad for needless foreign purchases.—Think it over and you will see we are right.

◈ ◈ ◈

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—Although no relief from the existing scarcity of foundry iron has yet been actually realised, it is satisfactory to note that extensive developments to provide increased furnace capacity to that end are now in view, the Cleveland ironmasters having decided on an immediate expansion of outputs to meet the growing needs of consumptive demand. In pursuance of this policy the local ironstone mines at Kilton are to be re-started at once, and additional batteries of coke ovens are being put into action, thus securing more ample supplies of raw materials conveniently close at hand. The prevailing scarcity of foundry pig is further reflected in the export market, shipments having fallen from 32,718 tons in May to 24,182 tons in June. An analysis shows that Belgium is now the biggest overseas buyer, parcels despatched to Belgian ports last month totalling 4,435 tons. Another effect of the local scarcity of raw materials is an increase of 6,000 tons in imports of iron and steel for the past month. In the meantime prices are a little easier, as indicated in the following current quotations:—No. 1 foundry, 75s.; No. 3 G.M.B., 72s. 6d.; No. 4 foundry, 71s. 6d., and No. 4 forge, 71s.

The market for North-East Coast hematite continues firm, but with the advantage of a fuller output than that of foundry pig, even the present active demand has not affected prices to any material extent, 74s. 6d. per ton being still the current quotation for mixed numbers. On the North-West Coast, Bessemer mixed numbers remain at 75s. per ton, at works.

LANCASHIRE.—At this period of the "Wakes" holiday season, market operations in foundry pig are usually quiet, but up to the present there has been no perceptible falling-off in contract deliveries. On the contrary, specifications have been on a particularly satisfactory scale. For the most part current quotations are nominal at 72s. per ton for Derbyshire No. 3, 73s. for Staffordshire, and from 91s. to 92s. for Scottish pig-iron, all delivered locally.

THE MIDLANDS.—At Birmingham this week demand for foundry pig continues active, but the bulk of the business transacted has been on forward account, mostly covering the current quarter, which is about the fullest extent makers now permit. Although at the recent meeting of the pig-iron producers no change was made in the zone figures, most of them are asking for a premium of 2s. 6d. per ton over the current levels, which are 73s. 6d. for Derbyshire No. 3, 74s. 6d. for North Staffordshire No. 3, and 70s. for Northants No. 3, delivered local stations.

SCOTLAND.—There is very little fresh business moving in this market, and, of course, the occasion of the annual holiday, which commences this week, is a factor in holding back possible orders. The local foundries are without any sign of improving business, and the quietness reported recently continues. Scotch foundry pig-iron is unaltered in price, 74s. 6d., and sellers will make no concessions.

Finished Iron.

Manufacturers in the Black Country area report that the demand for crown bars is somewhat better, and this is borne out by the fact that there is more business in forge pig-iron. The works making nut and bolt iron do not, however, find the position altering to any appreciable extent. Of course, they have to bear the brunt of the Continental competition. There has been no alteration in the prices. Staffordshire marked bars, for which the demand is of good proportions, are quoted at £12 at makers' works, and approved brands of crown bars of Staffordshire make are quoted at between £10 and £10 5s. It is possible, however, to get cheaper crown bars from this and other districts at prices between £9 10s. and £10, delivered into this area.

Steel.

At Sheffield the steel market is moderately active. There are heavy dealings in basic billets, and it is declared that at no period has there been a bigger production of basic steel in this district than at the present time. Acid billets make little progress. Prices are unchanged. The demand for finished steel is irregular, and while in some districts makers report good order books, in others there is a noticeable tendency for business to slow down. The export demand remains poor, as overseas makers continue to buy on hand-to-mouth lines. In the tin plate market inquiries are on a fairly good scale, with prices inclined to harden, the current figures for coke qualities being on the basis of 18s. 3d. to 18s. 4½d. for approved specifications, net cash, f.o.b. Wales.

Scrap.

July transactions in all descriptions of scrap metals is invariably regarded as a slack time for business, and this year offers no exception to the general rule. On the North-East Coast, however, there is still a fair demand, and the slight advance in heavy cast iron has been maintained, ordinary quality realising 66s. per ton at the foundries and good machining quality 68s. 6d. In the Midlands also dealers have no difficulty in selling available supplies of machinery cast-iron scrap in cupola sizes at 70s. to 72s. 6d. delivered, and light cast-iron scrap is firm at 60s. delivered. In Scotland the cast-iron scrap market is dull, first-class machinery quality being quoted at around 68s. 6d. to 70s., and heavy ordinary at 63s. 6d. Railway chairs are quiet at 66s., and light cast-iron scrap is 60s. The above prices are all per ton delivered free on truck at consumers' works.

Metals.

Copper.—Only a moderate amount of interest has been taken by operators in warrant copper during the current week, but, on the whole, quotations may be regarded as fairly stable in the existing conditions. With regard to the future, the outlook is uncertain, but the opinion is held in some quarters that the present level of values will be maintained, and that, if necessary, a further curtailment of the production will be adopted.

Closing quotations are :—

Cash.—Thursday, £72 10s. to £72 11s. 3d.; Friday, £71 17s. 6d. to £71 18s. 9d.; Monday, £72 8s. 9d. to £72 10s.; Tuesday, £72 3s. 9d. to £72 5s.; Wednesday, £71 13s. 9d. to £71 15s.

Three Months.—Thursday, £72 12s. 6d. to £72 15s.; Friday, £72 8s. 9d. to £72 10s.; Monday, £73 to £73 2s. 6d.; Tuesday, £72 13s. 9d. to £72 15s.; Wednesday, £72 2s. 6d. to £72 8s. 9d.

Tin.—Price indications of standard tin do not so far infer much influence derived from the issue of the June statistics hereunder summarised, while the effect of the formation of the new controlling interests has yet to be ascertained. The official figures show that there is practically no alteration in the visible supply, while the market forecast was for an increase of about 6,000 tons.

TOTAL VISIBLE SUPPLY.—Month's shipments, 9,467 tons; other afloat, 2,238 tons; total afloat, 11,705 tons; landing, 2,955 tons; in warehouse, 9,091 tons; total stocks, 12,046 tons. Total visible supply, 23,751 tons.

Official closing prices :—

Cash.—Thursday, £204 to £204 5s.; Friday, £204 5s. to £204 10s.; Monday, £204 10s. to £204 12s. 6d.; Tuesday, £204 10s. to £204 12s. 6d.; Wednesday, £205 10s. to £205 12s. 6d.

Three Months.—Thursday, £207 2s. 6d. to £207 7s. 6d.; Friday, £207 12s. 6d. to £207 15s.; **Monday, £207 12s. 6d. to £207 15s.; Tuesday,** £207 15s. to £207 17s. 6d.; Wednesday, £208 15s. to £208 17s. 6d.

Spelter.—The market for ordinary spelter has recently experienced a reaction, and despite the efforts of the Syndicate with a view to an extensive reduction of production, values have had a weaker tendency.

Daily quotations are :—

Ordinary.—Thursday, £25 8s. 9d.; Friday, £25 8s. 9d.; Monday, £25 10s.; Tuesday, £25 17s. 6d.; Wednesday, £25 15s.

Lead.—Quiet conditions continue on the lead market, and values, as a result of a quieter demand, have eased off a little. At the half-yearly meeting of the lead producers held recently it was found that the statistics showed that there was no need to take any action to reduce the output, and it was agreed to continue for six months the arrangement, made last year, imposing a restriction in the event of any adverse change in the situation.

Prices have been :—

Soft Foreign Prompt.—Thursday, £22 15s.; Friday, £22 17s. 6d.; Monday, £22 17s. 6d.; Tuesday, £23 1s. 3d.; Wednesday, £22 18s. 9d.

French Founders Entertain American Delegation.

On the termination of the International Foundry Congress a number of American visitors crossed to Paris, and were informally received by the Association Technique de Fonderie. The guests were entertained on June 27 at a banquet held at the Hôtel Weber. Mr. Damour, President of the Association, acted as chairman, and amongst those present were Mr. S. W. Utley, Vice-President of the A.F.A., and Mrs. Utley; Mr. Fred Erb, President-Elect, and Mrs. Erb; Mr. and Mrs. Dodge; Mr. Gibeny; Mr. and Mrs. Grede; Mr. and Mrs. Hanley; Mr. and Mrs. Hageboek; Mrs. Kurty, and Mr. and Mrs. Schneider. Other prominent figures present were Mr. Jordan, of the New York Bureau of Information on Nickel; Mr. W. T. MacLellan, of the Bengal Iron Company, and Mr. J. C. Mahindra, of Bombay. Amongst the French foundrymen present were Mr. Ronceray, Mr. Ramas, Mr. Koelher, Mr. Maxime Plichon, Mr. Magdelenat, Mr. Montupet, Mr. Penicud and Mr. Rousseau.

Speeches were made by the chairman, who recalled his first visit to Philadelphia in 1906; Mr. Ronceray, who has on several occasions visited the U.S.A., and Mr. Maxime Plichon, who spoke on behalf of the Employers' Federation. Replies were made by Mr. Utley, who stressed the influence the French had on American foundry practice, especially in Detroit, and Mr. Erb, who mentioned the fact that Mr. Maxime Plichon was the brother of Mr. Lucien Plichon, who was in 1906 casting automobile cylinders for the Packard Company, where he was manager. He pointed out that Mr. Montupet was the first foundryman to make aluminium castings in sand, this being in 1898, long before the founders in other countries.

The evening was terminated by an informal dance.

Development of Chilean Iron and Steel Industry.

In order to free local industries from domination by foreign suppliers of raw materials, the Chilean Government has enacted a law which authorises the President to invest, for the account of the State, 40,000,000 Chilean pesos [about £6,000,000] in taking up two-thirds of the shares in a corporation which is being formed in Southern Chile for the production of iron and steel.

The company, which will have five Government directors out of seven, proposes to build electric blast furnaces near Port Carral, and hopes within 18 months to be able to deliver iron and steel rails, bars, plates, and wire, thereby cutting down substantially the importation of iron and steel products from Europe and America, which now amount to nearly 230,000 tons yearly.

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LESS FETTLING
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CLEANER CASTINGS

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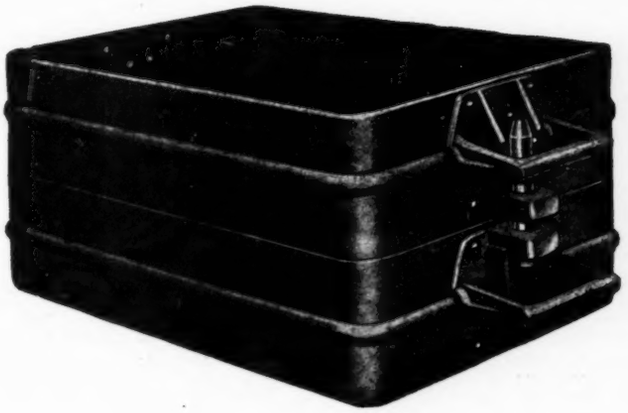

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WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	71	13	9
Three months	72	2	6
Electrolytic	84	0	0
Tough	74	15	0
Best selected	75	0	0
Sheets	110	0	0
India	93	0	0
Wire bars	84	10	0
Do. Aug.	84	10	0
Do. Sept.	84	10	0
Ingot bars	84	10	0
H.C. wire rods	86	15	0
Off. av. cash, June	74	7	9
Do. 3 mths., June	73	19	3½
Do., Sttlmnt., June	74	8	0
Do., Electro, June	84	7	0
Do., B.S., June	77	8	1½
Aver. spot price, copper, June	74	7	9
Do. wire bars, June	84	13	9
Solid drawn tubes			15½d.
Brazed tubes			15½d.
Wire			12½d.

BRASS.

Solid drawn tubes	13d.
Brazed tubes	15d.
Rods, drawn	12½d.
Rods, extd. or rlld.	8½d.
Sheets to 10 w.g.	11½d.
Wire	11½d.
Rolled metal	10½d.
Yellow metal rods	8½d.
Do. 4 × 4 Squares	9d.
Do. 4 × 3 Sheets	9½d.

TIN.

	£	s.	d.
Standard cash	205	10	0
Three months	208	15	0
English	206	0	0
Bars	207	0	0
Straits	208	0	0
Australian	206	15	0
Eastern	210	5	0
Banca	Nominal		
Off. av. cash, June	200	5	9¾
Do., 3 mths., June	203	9	6
Do., Sttlmt., June	200	5	4½
Aver. spot, June	200	5	9½

SPELTER.

Ordinary	25	15	0
Remelted	23	15	0
Hard	21	5	0
Electro 99.9	28	0	0
English	26	5	0
India	23	0	0
Zinc dust	(Nom.) 34	10	0
Zinc ashes	8	15	0
Off. aver., June	26	2	0
Aver., spot, June	26	4	3¾

LEAD.

Soft foreign ppt.	22	18	9
English	24	10	0
Off. average, June	23	12	11½
Average spot, June	23	13	10½

ZINC SHEETS, &c.

Zinc sheets, English	34	10	0
Do. V.M. ex whf.	32	12	6
Rods	40	0	0
Boiler plates	30	10	0
Battery plates	31	0	0

ANTIMONY.

Special brands, Eng.	50 5 0
Chinese	33 10 0
Crude	Nominal

QUICKSILVER.

Quicksilver	22	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	7 15 0
45/50%	12 0 0
75%	19 5 0
Ferro-vanadium—	
35/50%	12/9 lb. Va.
Ferro-molybdenum—	
70/75% c. free	4/- lb. Mo.
Ferro-titanium—	
23/25% carbonless	11d. lb.
Ferro-phosphorus, 20/25%	£16 0 0
Ferro-tungsten—	
80/85%, c. fr.	2/9 lb.
Tungsten metal powder—	
98/99%	3/- lb.
Ferro-chrome—	
2/4% car.	£32 10 0
4/6% car.	£23 12 6
6/8% car.	£22 18 0
8/10% car.	£22 12 6
Ferro-chrome—	
Max. 2% car.	£33 12 6
Max. 1% car.	£37 10 0
Max. 0·70% car.	£41 7 6
70%, carbonless	1/2 lb.
Nickel—99% cubes, or pellets	£175 0 0
Ferro-cobalt	9/4 lb.
Aluminium 98/99%	£95 0 0
Metallic chromium—	
96/98%	2/6 lb.
Ferro-manganese (net)—	
76/80% loose	£13 15 0
76/80% packed	£14 15 0
76/80%, export	£14 10 0
Metallic manganese—	
94/96%, carbonless	1/6 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 0
Finshed bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{7}{16}$ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	3	17	6 to	3	18	6
Bundled steel and shrngs.	3	15	0 to	3	16	6
Mixed iron and steel	3	10	0 to	3	12	6
Heavy cast iron				3	2	6
Good machinery for foundries	3	5	0 to	3	7	6
Cleveland—						
Heavy steel				3	5	0
Steel turnings				2	17	6
Cast iron borings				2	17	6
Heavy forge				3	17	6
W.I. piling scrap				3	12	6
Cast-iron scrap	3	6	0 to	3	8	6
Lancashire—						
Cast-iron scrap	3	0	0 to	3	10	0
Hvy. wrought				3	12	6
Steel turnings				2	17	6
Scotland—						
Heavy steel				3	15	6
Cast-iron borings				2	14	6
Wrought-iron piling				3	13	0
Heavy machinery				3	10	0

London—Merchants' buying prices delivered yard.

Copper (clean)	62	0	0
Brass	42	0	0
Lead (less usual draft)	20	0	0
Tea lead	16	10	0
Zinc	17	0	0
New aluminium cuttings	68	0	0
Braziery copper	54	0	0
Gunmetal	54	0	0
Hollow pewter	160	0	0
Shaped black pewter	106	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	75/-
Foundry No. 3	72/6
Foundry No. 4	71/6
Forge No. 4	71/-
Hematite No. 1	75/-
Hematite M/Nos.	74/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/-
„ d/d Birm.	91/-
Midlands—	
Staffs. common*	—
„ No. 4 forge*	70/6
„ No. 3 fdry*	74/6
Shrops. basic	—
„ Cold blast, ord.	—
„ „ roll iron	—
Northants forge*	66/-
„ fdry. No. 3*	70/-
Derbyshire forge*	69/6
„ fdry. No. 3*	73/6
„ basic*	—
* d/d Black Country dist.	
Scotland—	
Foundry No. 1	77/-
„ No. 3	74/6
Hem. M/Nos.	80/-
Sheffield (d/d district)—	
Derby forge	64/6
„ fdry. No. 3	68/6
Lincs. forge	—
„ fdry. No. 3	72/6
E.C. hematite	86/-
W.C. hematite	87/-
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
„ fdry. No. 3	72/-
Northants foundry No. 3	—
Dalzell, No 3 (special)	102/6 to 105/-
Summerlee, No. 3	92/-
Glengarnock, No. 3	—
Gartsherrie, No. 3	92/-
Monkland, No. 3	92/-
Shotts, No. 3	92/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.	£	s.	d.
Iron—						
Bars (cr.) nom.				10	15	0
Nut and bolt iron				9	5	0
Hoops	11	0	0 to	11	10	0
Marked bars (Staffs.) f.o.t.				12	0	0
Gas strip	11	0	0 to	11	10	0
Bolts and nuts, ¾ in. × 4 in.				15	5	0
Steel—						
Ship plates	8	12	6 to	8	17	6
Boiler plts.				10	10	0
Chequer plts.				10	12	6
Angles				8	2	6
Tees				9	2	6
Joists				8	2	6
Rounds and squares, 3 in. to 5½ in.				9	2	6
Rounds under 3 in. to ⅜ in. (Untested)				8	0	0
				and upwards		
Flats, over 5 in. wide and up				8	7	6
Flats, 5 in. to 1½ in.				7	17	6
Rails, heavy				8	10	0
Fishplates				12	10	0
Hoops (Staffs.)	10	0	0 to	10	10	0
Black sheets, 24g.	10	5	0 to	10	10	0
Galv.cor.shts., 24g.	13	2	6 to	13	10	0
Galv. fencing wire 8g. plain				12	0	0
Billets, soft	6	10	0 to	7	0	0
Billets, hard	7	12	6 to	8	2	6
Sheet bars	6	5	0 to	6	10	0
Tin bars	6	5	0 to	6	10	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/4
Sheet to 10 w.g.	1/5
Wire	1/6½
Rods	1/5
Tubes	1/9
Castings	1/4

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	10d. to 1/4
Rolled—	
To 9 in. wide	1/4 to 1/10
To 12 in. wide	1/4½ to 1/10½
To 15 in. wide	1/4½ to 1/10½
To 18 in. wide	1/5 to 1/11
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6 to 2/-
Ingots for spoons and forks	10d. to 1/6½
Ingots rolled to spoon size	1/1 to 1/9½
Wire round—	
3/0 to 10 G.	1/7½ to 2/2½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	15.00
Basic	20.26
Bessemer	20.76
Malleable	20.76
Grey forge	19.76
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bessemer billets	35.00
O.-h. billets	34.00
O.-h. sheet bars	35.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.95
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.60
Sheets, blue an'l'd, No. 13	2.35
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.30
Tinplates, 100 lb. box	$5.35

COKE (at ovens).

Welsh foundry	23/- to 27/-
„ furnace	21/- to 23/-
Durham and North.	
„ foundry	17/6 to 20/-
„ furnace	18/9
Midlands, foundry	—
„ furnace	19/- and up

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box		18/3
„	28×20 „		36/6
„	20×10 „		26/3
„	18¾×14 „		18/9
C.W.	20×14 „		15/3
„	28×20 „		33/6
„	20×10 „		21/3
„	18¾×14 „		16/-
Terneplates	28×20		33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0 to	£7	10	0
Bars, hammered, basis	£17	10	0 to	£18	10	0
Bars and nail-rods, rolled, basis	£15	15	0 to	£16	15	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£32	0	0 to	£33	0	0
Faggot steel	£20	0	0 to	£24	0	0
Bars and rods, dead soft, steel	£10	0	0 to	£14	0	0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½%	50%
Water	63½%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£ s. d.		
July	4	72 10 0	dec.	7/6
,,	5	71 17 6	,,	12/6
,,	8	72 8 9	inc.	11/3
,,	9	72 3 9	dec.	5/–
,,	10	71 13 9	,,	10/–

Electrolytic Copper.

		£ s. d.			
July	4	84 0 0	dec.	10/–	
,,	5	84 0 0	No	change	
,,	8	84 0 0	,,	,,	,,
,,	9	84 0 0	,,	,,	,,
,,	10	84 0 0	,,	,,	,,

Standard Tin (cash).

		£ s. d.			
July	4	204 0 0	No	change	
,,	5	204 5 0	inc.	5/–	
,,	8	204 10 0	,,	5/–	
,,	9	204 10 0	No	change	
,,	10	205 10 0	inc.	20/–	

Tin (English ingots).

		£ s. d.			
July	4	204 10 0	No	change	
,,	5	205 0 0	inc.	10/–	
,,	8	205 0 0	No	change	
,,	9	205 0 0	,,	,,	,,
,,	10	206 0 0	inc.	20/–	

Zinc Sheets (English).

		£ s. d.			
July	4	34 10 0	dec.	10/–	
,,	5	34 10 0	No	change	
,,	8	34 10 0	,,	,,	,,
,,	9	34 10 0	,,	,,	,,
,,	10	34 10 0	,,	,,	,,

Spelter (ordinary).

		£ s. d.			
July	4	25 8 9	No	change	
,,	5	25 8 9	,,	,,	
,,	8	25 10 0	inc.	1/3	
,,	9	25 17 6	,,	7/6	
,,	10	25 15 0	dec.	2/6	

Lead (English).

		£ s. d.			
July	4	24 5 0	dec.	5/–	
,,	5	24 5 0	No	change	
,,	8	24 5 0	,,	,,	
,,	9	24 10 0	inc.	5/–	
,,	10	24 10 0	No	change	

AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	4 15 0	4 17 6	5 0 0	5 0 0	5 0 0	4 17 6	4 17 6	4 17 6	4 17 6	5 0 0	5 7 6	5 7 6	4 19 9½
1897	5 7 6	5 7 6	5 7 6	5 5 0	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 2 6	5 0 0	5 5 0	5 3 5½
1898	5 5 0	5 5 0	5 5 0	5 7 6	5 13 9	5 15 0	5 15 0	5 15 0	5 17 6	6 0 0	6 5 0	6 7 6	5 14 3
1899	6 10 0	6 12 6	6 15 0	6 15 0	6 17 6	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7½
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 6 3	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4½
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 13 4
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	6 12 6	7 0 5
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 16 3
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3½
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 7 8½	
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 12 6	7 14 6	7 17 6	7 7 4½
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	7 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6½
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	18 5 0	16 1 9
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	22 19 2
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	9 12 6	15 11 7
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 0	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 5 0	9 13 1½
1925	9 2 0	9 0 11½	9 0 0	8 15 9	8 10 3½	8 9 0½	8 6 3	8 2 6	7 19 0½	7 12 3	7 5 0	7 2 6	8 5 5½
1926	7 2 6	7 2 6	7 2 6	7 3 4	7 2 6	7 3 9	7 7 6	7 8 5½	7 9 0	7 12 6	7 16 3	8 0 6	7 7 7½
1927	7 18 9	7 17 6	7 17 6	7 14 8½	7 13 9	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 14 1½
1928	7 12 6	7 14 9	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 16 10½
1929	7 17 6	7 17 6	7 17 6	7 17 6	8 0 6	8 2 6	—	—	—	—	—	—	—

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